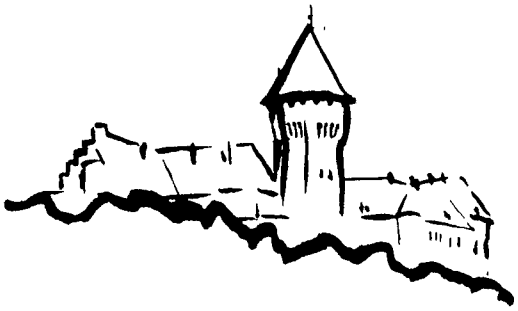
International Symposium on Geomorphic Response to Land Use Changes

May 29 - June 2, 2000, Smolenice, Slovak Republic



ABSTRACTS

including the List of Participants

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INTERNATIONAL SYMPOSIUM ON GEOMORPHIC RESPONSE TO LAND USE CHANGES

May 29 - June 2, 2000, Smolenice, Slovak Republic

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INFLUENCE OF DISASTROUS PRECIPITATION ON LANDSLIDE SLOPES DEVELOPMENT AND THEIR USE IN THE POLISH FLYSCH CARPATHIANS

Bajgier-Kowalska, M.

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Gravitational movements of rocky masses in the flysch Carpathians are accordant to morphodynamic levels, which were influenced by step-like Carpathian relief and climatic zones. At the end of the Ice age and in the Holocene morphodynamic levels were unstable and underwent changes. At present there can be distinguished three levels: high montane (cryonival), middle montane (beskidian) and foreland. The cryonival level is characterised by regional, step-like relief with terraces and cryoplanation plains and great areas of debris overgrown at present with dwarf pine. There are collections of weathering-debris covers, which give the beginnings to debris flows during rapid heavy rainfalls. The beskidian level slopes are shaped by deep rocky landslides, which are both in spring areas, and on slopes. The best preserved are the niches of those landslides down which there are numerous flattenings, ramparts and cracks built of rocky packs and debris. Lower situated ramparts become debris fields. In the foreland level there are numerous rocky-weathering landslides which are some metres thick. These are plastic-argillaceous landslides with great frequency of rejuvenation. During wet periods of time the edges withdraw continually or periodically and the landslide areas are enlarged.

Landslides played an important role in the early stages of settlement in the Carpathians. Archaeological researches pointed out that the best places for the early settlement were the flattenings within landslide niches during the migration of the latene culture (2350-1950 years BC). Deep cracks and dilatational caves were well located in the upper parts of mountains, not available during military actions. Next wave of settlement connected with tribes migrations (8^{th} - 9^{th} century) and with wołoska colonisation (15^{th}-16^{th} century) covered the upper parts of landslide flattenings and the present breeding activities in the upper parts of the Beskidy is probably the continuation of the older phases of settlement.

Nearly 90 % of the landslides in the Beskidy are overgrown with forests and only in the upper parts numerous flattenings and depressions are overgrown with montane meadows. Variability of geomorphological (great landslide areas) and soil conditions in the Beskidy is reflected in arable and forest land. It is confirmed by ecological soil and habitat inversion what means that grassland overgrown sometimes higher located but more gentle parts of slopes with deeper and less skeleton soils and forests grow on lower parts of slopes with muck-stony soils. It is connected with frequent rejuvenation or landslide dissections in the lower part. The predominant form of land use in the Beskidy are forest areas. Slope forestation increases with the height above sea level and above 700 m it reaches 80 %. Grasslands of the highest level make mainly meadows of anthropogenic origin, which are above the tree line. There are numerous inter forest meadows within flattenings in landslide niches. Great frequency of landslide processes on the Carpathian foreland makes economic activity of a man more difficult. Landslides used as pastures in the wet periods of time become waste land overgrown with bushes or peat. If landslide tongues reach greater valleys, during high water level are undercut and landslide material is carried away by flood waters. That process causes further landslide movements, which make that the area of arable land decreases, and grassland or waste land areas increase.

In the years 1996-1997 there were disastrous floods in the Carpathians during which slope stability ratios were exceeded. There occurred landslides at unparalleled scale, which completely

changed agrar slope use. Debris flows were formed debris flows, which destroyed dwarf pine overgrowing debris slopes (Babia Góra, Pilsko). Deep rocky landslides were dissected by debris-mud flows which, on lower situated agrar areas, made big torrential cones. Debris-mud deposits in many places filled inter landslide depressions used earlier as meadows and pastures. Some of inlandslide lakes were filled with clay material. Rocky-weathering landslides that shaped lower parts of slopes were enlarged and forests growing on them were destroyed. The greatest damages concerned arable land mainly because of wash outs, mud-debris flows and enlargement of landslide area. Those damages in particular gminas (administrative districts) reached 600 000 USD (gmina Limanowa). Great damages concerned also forests (5 %) and loss reached 1 830 000 USD in the Beskid Wyspowy.

THE INFLUENCE OF CONTEMPORARY SLOPE PROCESSES ON CHANGES OF LAND USE IN WĄWOLNICA COUNTY (SE POLAND)

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There is a bilateral dependence between slope processes dynamics and the way land is used. Gradually increasing deforestation was a result of agricultural human activity that had taken place on loess uplands since Neolithic age. As natural vegetation cover on areas of strongly diversified relief was destroyed, the processes connected to water flow and wind along with direct agricultural tools influence, started to develop dynamically. Soil erosion processes and ravine erosion developed on a large scale. The dynamics of relief transformation changed along with changes of agricultural land use intensity, and the largest transformations took place between 13th and 20th century. In the second part of the 20th century a new tendency in agricultural land use appeared. On intensive relief, loess uplands areas of South Eastern Poland a gradual decrease of ploughed areas may be observed, while forested and turfed areas become larger. It is caused by progressive fields dispersion (difficulties with getting to fields), agriculture mechanisation and the decrease of agriculture production profitability, especially on areas of productivity reduced by erosion.

Wąwolnica County, covering an area of 63 km^2, is located in the North Western part of Lublin Upland. In the northern, loess part of the county a lively, young erosion relief with big relative heights, dense valleys net and significant dynamics of relief processes is a characteristic feature. Southern part is of typically plateau relief, wavy interfluve areas are slightly incised here. Wąwolnica County is an agricultural county – ploughing grounds cover 63 % of its area, while forests less than 12 %. Favourable natural and human conditions – loess cover, dense net of valleys with steep slopes, significant deforestation – initiate dynamic morphogenetic processes on a part of county area. The most rapidly transforming elements are steep slopes used as ploughing grounds, some gullies, road ravines, active proluvial fans. Areas of big and very big processes dynamics embrace about 14 % of county area. Data concerning mechanical denudation form some kind of indicator of processes intensity on the analysed area: an average 5-year suspension outflow amounts to 16 t.km^{-2} per year for Bystra River basin, and for smaller basins (of a few dozen square kilometres) this rate is estimated at 40-50 t.km^{-2} per year.

Within the last period of time on the county area an increase of forested domain is observed. It amounted to 37 % within last 30 years (forest rate increase from 7.5 % to 10.2 %). Reasons of this type of transformations may be searched for in geomorphological conditions of the described area. Detailed field observations show that excluding fields from ploughing concerns first of all steep slopes and areas located close to gullies. Significant slope processes dynamics is a characteristic feature of these areas, so the risk of crops devastation as a result of intensive rill erosion is considerable. This fact, along with difficulties of mechanical tillage on areas of substantial inclination, ceases ploughing on such domains. Next, it contributes to decrease of lands of significant slope processes dynamics. This tendency may be upset as a result of fields integration projects which do not take the relief into consideration. Improper fields combining may contribute to repeated increase of morphogenetic processes dynamics.

On the described area, as a result of dynamic slope processes, numerous, high tillage escarpments and deep road incisions appear. They are often overgrown with bushes and trees slowly entering adjacent agricultural areas. History of county land use transformations and processes dynamics changes connected to it, may be presented as follows: significant deforestation (starting at the late Middle Ages) => increase of slope processes dynamics => considerable relief transformation => slow increase of forest areas (second half of the 20th century) => decrease of morphogenetic processes intensity on some areas.

GEOMORPHOLOGY AND ENVIRONMENTAL IMPACT ASSESSMENT IN A SKIING AREA (SÖLDEN, TYROLEAN ALPS)

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This study is part of the TMR-Project "*A European Research Network for the Application of Geomorphology and Environmental Impact Assessment to Transportation Systems*", sponsored by the European Union. It's aim is to identify the direct impacts caused by the ski-run construction on the geomorphologic assets and to establish a zonation of what has come out to be the most relevant natural hazard of the area: snow avalanches. The interpretation of aerial photographs, the field geomorphologic survey and the use of GIS packages were the key instruments used for this research.

EFFECTS OF LAND USE CHANGES AND HUMAN IMPACT ON FLUVIAL PROCESSES: EXAMPLES FROM FEW RIVERS OF TUSCANY, ITALY

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In this presentation the interaction among land use and management, river exploitation and river morphological response is reported for different fluvial systems of Tuscany in central Italy. In this area man has been playing a very important role since the dawn of civilisation as he tried to impose to the fluvial environment a newly designed equilibrium based on the will to benefit from the natural resources available and the need to reduce the main, unwanted (but often unconsciously accentuated by himself) negative responses of the natural system such as land degradation or devastating floods. For more than 2000 years the rivers of Tuscany underwent a number of interventions at basin scale (deforestation, wide changes in land use and reclamation of large areas) and in-channel engineering works (levee construction, artificial meander cut-offs, diversions, weir construction, bed material harvesting, etc.). The sequence of alternating depositional and erosive phases, due to many of the above impacts, is well documented for the delta and the channel of the Arno River (the largest of Tuscany). During the last four decades, many rivers were affected by an alteration of the sediment budget caused by a combination of factors such as population internal migrations (cropland abandonment in mountain areas and intensification of human pressure on the flood plains), reforestation and stream bed material exploitation. This remarkably increased riverbed degradation and channel geometry adjustments. Rivers that presented a wide thalweg, commonly with multiple channels, changed in to narrow single channel stream. The recent prohibition of bed material excavation, is now favouring a spontaneous rehabilitation of some riverbeds that is not free of criticism by flood plain farmers and owners as the channel widening takes place through extensive bank erosion. Examples of such river metamorphoses will be reported and discussed. Finally, the augmented, negative effects of a very intense rainfall and the extreme flood and land degradation associated, that affected a mountain stream of northern Tuscany in 1996, are discussed in the view of changes in the management of the chestnut three forest in the catchment headwaters.

QUANTIFICATION OF GEOMORPHIC RESPONSES TO LAND USE: METHODS, EXAMPLES AND RULES

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Man has enabled changes of the topography due to soil erosion by water and wind since the introduction of agriculture. The changes of the topography can be reconstructed and quantified by detailed soil and sediment profile analysis. Examples from Chile, the USA, and Germany highlight the variability of the causes and the effects of land use changes on the topography, and of the processes involved.

The suspended load of the irrigation water build up several oasis in the Salar de Atacama, Chile, since 2500 BP. Land use has changed the topography since then. In the late 20th century failures in the irrigation procedure destroyed many terraces.

European farmers were arriving in high numbers in the late 19th century in the Pacific Northwest of the USA. Namely in the first half of the 20th century wide areas were devastated in Washington and Oregon by gully erosion on rangeland and farmland. Extreme tillage translocation and sheet erosion changed the topography of the Palouse region in Eastern Washington since the 1930s. Rates of more than 100 tons of soil movement per hectare and year were reconstructed and related to land use changes.

In Germany slight soil erosion dominated in arable land from Neolithic ages to early Medieval Times. Major changes of the topography, enabled by intensive agricultural land use, certain landscape structures and caused by catastrophic rainfall, occurred in wide parts of Central Europe in the 14th and 18th centuries. Accelerated land-use-induced changes of the topography can be found in the late 20th century too.

General rules concerning the influence of different land use types on the topography are presented in the last part of the paper.

GEOMORPHOLOGIC CONSEQUENCES OF HEAVY RAINFALL ON 2.6.1998 IN IDJEVAN (ARMENIA)

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Town Idjevan is situated in north-eastern part of Armenia, on right bank of river Aghstev, absolute altitudes of 600-800 m, in forest zone. Here average quantity of precipitations is 557 $mm.year^{-1}$ (data for 30 years), maximum is 738 $mm.year^{-1}$. The most precipitation fell in May-July.

In 1998 precipitation amounted 545 mm with maximum in May-June, but the most daily quantity in June-July (57.5 and 30.2 mm). In this period lengthy rains fell in Idjevan region during the whole May. They moistened ground by water very much. Heavy rain fell on 1-2 June, as a result of that 70 mm of precipitation (53 mm of it during 50 minutes in 2 June) fell in town Idjevan and its environs.

At that time mud flow was formed in upper course of temporary stream on right bank of river Aghstev. It suddenly fell in the northern outskirts of town. The water level in balkas rose of 1-1.2 m, and this water-mud and water-stone stream, got away from beds of balkas, rushed on two streets, carrying everything before it: concrete blocks, pipes, small temporary buildings, boulders, soil cover of kitchen gardens and gardens together with plantations and trees. Mud flow damaged foundation of some houses, filled basements by liquid mud, ground of power- station and took out a great number boulders to street Highgestan.

Troubled situation was created for inhabitants of four high-riser houses, built on alluvial fun of temporary stream on northern outskirts of Idjevan. Basements of these houses are filled of 1.5-2 m by liquid mud, which damaged sewage system. The gully of 2.5 m depth was formed on the southern side of these houses, but on the northern side mud flow eroded the alluvial fun and displaced active bed of stream to houses of 3-3.5 m. Ground of these houses was eroded from three sides: from two sides by mud flow and one side by river Aghstev, the level of which rose of 50 cm at that time.

Our researches showed that building of dwelling houses, different structures, placing of kitchen gardens was here made without consideration of mud flow's danger and without some defence from ones.

At present, we carry out valuation of all neighbouring streams and even small balkas for mud flow's danger and elaborate complex of protective measures for each concrete area.

RIVER STYLES: A GEOMORPHIC TEMPLATE FOR CATCHMENT-WIDE ANALYSIS OF RIVER CHARACTER, BEHAVIOUR, CONDITION AND RECOVERY POTENTIAL

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Putting aside the impacts of aboriginal practices, such as alterations to the 'natural' fire regime, assessment of the geomorphic condition of rivers at the time of European settlement (i.e. 1788) provides an idealised platform upon which to analyse the nature and extent of subsequent river changes. Based on interpretation of the pathways of river change (i.e. degradation) away from this 'intact' or pre-disturbance condition, it is possible to determine practical guidelines with which to identify attainable conditions for management efforts at river rehabilitation. This notion builds directly on the premise that 'working with nature' provides the most appropriate framework for management efforts. To achieve this goal, efforts at river rehabilitation must appreciate the stage and direction of river degradation and/or recovery (i.e. whether the geomorphic condition of the river is improving, or continues to deteriorate).

Rivers throughout southeastern Australia have been subjected to varying degrees of degradation in the period since European settlement. In many instances, changes have been so pronounced that to all intents and purposes they are irreversible. Elsewhere, rivers can be considered to be at differing stages of recovery. In the River Styles framework, developed by Gary Brierley and Kirstie Fryirs at Macquarie University, the character, capacity and stages of river recovery are determined for rivers across the range of natural variability. A generic procedure to measure river recovery is developed and applied in Bega catchment, on the south coast of New South Wales (NSW), Australia.

Five categories of river condition are identified. *Intact* reaches operate in a self-adjusting manner, whereby processes maintain the pre-disturbance geomorphic character of the reach. The processes occurring in *restoration* reaches maintain and enhance the geomorphic structure of the reach. These reaches are moderately resilient to change. The river has experienced degradation, but has recovered to a condition approximating its pre-disturbance character and behaviour. *Degraded* reaches are still adjusting to disturbance and the processes of recovery have not yet begun. The river is experiencing progressive deterioration away from the structure and function of the pre-disturbance condition. *Turning point* reaches are at the transitional stage where they can either recover or revert to a degraded state. Finally, a *creation* reach has a self-adjusting character and behaviour but operates under altered catchment boundary conditions. The character and behaviour of the river do not equate to pre-disturbance conditions, rather, the river is well adjusted to prevailing catchment boundary conditions of water and sediment transfer, and vegetation cover and composition (among many factors). From these bases of information, a catchment-wide prioritisation procedure for river management activities is applied, striving to attain self-sustaining river courses and associated aquatic ecosystems.

GEOMORPHOLOGICAL RESPONSES TO GRAZING IN SOUTHERN BOLIVIAN ECOSYSTEMS

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The interaction between erosion processes on soil and vegetation was studied in three different ecosystems in the southern Bolivian Andes. The study area covers the main Central Andean ecosystems *i.e.* High Andean plateau, Inter-Andean valley and Sub-Andean valley. The introduction of cattle, sheep and goats 500 years ago has been a major change in land use in the Andes. The objective was to understand to what extent land use changes have been responsible for the very severe erosion that has occurred.

The impact of grazing on soil properties and biomass in the major geomorphological units was studied. Data from 25 representative sites is presented and analysed in the paper. In general it can be concluded that grazing reduces biomass to values of 2 000-7 000 $kg.ha^{-1}$ in the Sub-Andean valley and 1 000-2 000 $kg.ha^{-1}$ on the High Andean plateau. Organic matter contents of less than 1 % were found in grazing lands and P and available water contents were low.

It was found that although the current grazing intensity is low, large areas are nevertheless affected by severe erosion. This is due to the high erodibility of the parent material and the semi-arid climatic conditions. Erosion features such as badlands, dunes and stripped bedrock are widespread and reflect different erosion scales in time, space and magnitude. Remnants of well-developed soil profiles on steep slopes suggest stable conditions for long periods of time. The distribution of non-degraded soils is clearly related to the geomorphological position of the site.

The geomorphological response to grazing is complex due to the interaction with land use, geology and climate. Moreover, the nature and intensity of grazing have changed continuously the last 500 years, especially in the Sub-Andean valley. It is very difficult to obtain quantitative information about past grazing intensities. An apparent recent reduction in grazing intensity does not seem to have resulted in less erosion. This suggests that former grazing intensity has changed the ecosystem vulnerability to erosion to such extent, that erosion rates are high despite current low grazing intensity.

GEOMORPHOLOGICAL RESPONSE TO THE DEVELOPMENT OF AGRICULTURE IN THE EAST OF THE RUSSIAN PLAIN

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The comparison of the character and intensity of exodynamical processes in the regions with different degrees of agricultural development allowed us to estimate the role of anthropogeneous factor in the course of these processes. Extermination of forests and ploughing up of land have increased the surface runoff of water and repeatedly intensified the processes of soil and ravine erosion in reservoirs and its product accumulation in valleys. Suspended sediment yield has increased 6 times for small rivers and 3 times for big ones, the positive dependence of specific sediment yield on basin areas characteristic of natural landscapes has been replaced by the negative one. The surface chemical denudation and deflation have also increased.

The decrease of infiltration of small and rain waters has resulted in complete or partial draining of ground water horizons and drying out of many hundreds of small rivers. The intensity of subsurface chemical denudation, suffosion and landslides has decreased. As a whole the entire spectrum of exogeneous processes has changed in favour of aridisation. Extreme displays of the processes have intensified.

During the last decades was a slightly descending trend in the development of erosion and a member of other processes determined, which can be explained by the effect of both natural factors (the decrease of continentality of climate) and anthropogeneous ones (the reduction of arable lands, replacement of agricultural crops, measures against erosion).

SEDIMENT YIELD AS A FUNCTION OF BASIN AREA AND THEIR AGRICULTURAL USE

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Downstream the rivers the changes of runoff and sediment yield take place according to increasing of catchment areas and their agricultural use. For analysis the data for small and middle rivers of plains and low mountains temperate belts with basin areas up to 100 000 km^2 were used. Two large distinct groups are observed for studied rivers with respect to correlation between suspended sediment yield and basin areas.

For the rivers, the basin of which preserve natural of slightly changed by human activity landscape (the rivers of first category - forest >70 %, cultivation <30 %) suspended sediment mass downstream increases than basin area (Rn/Rm > Sn/Sm, where Rn and Sn are suspended sediment mass and basin area, respectively, for the upper course of rivers, Rm and Sn are those for the lower course). The downstream increase of specific suspended sediment mass and basin area, respectively, for the upper course of rivers, (Rn/Rm > Sn/Sm, where Rn and Sn are those for the lower course). The downstream increase of specific suspended sediment yield both integral, characteristic for the total area of the basin above the given point ($r = R/St\ km^{-2}.year^{-1}$), is also a regular phenomenon. Differential specific yields increase much faster, than integral ones downstream. The mentioned regularities result from the fact that (sheet and gully) erosion is negligible and the main role belongs to channel erosion.

The rivers with rather intensively cultivated basins (the third category - forest <30 %, cultivation >50 %) are also characterised by increase of suspended sediment mass downstream, but this increase occurs slower than the basin area increase (Rn/Rm<Sn/Sm). Moreover, the sediment mass in the lower courses quite often decreases due to its partial accumulation. Corresponding the specific suspended sediment yield both integral, and to even more extent differential, decrease downstream. Accumulation quite often prevails over erosion in the lower rivers and specific sediment yield becomes negative. Such reverse (negative) relation results from the fact, that intensive basin erosion on cultivated soil during melting of the snow or heavy rains provides much sediment far most in the upper rivers. The rivers are overloaded with sediments, and partially accumulate them, which results in specific sediment yield decrease. During the low water period the basin erosion ceases, and direct (positive) relation between sediment yield and basin area is established.

Both considered dependencies are disturbed by creation reservoirs, severe changes of geological and landscape conditions. These dependencies are not distinctly expressed for the rivers with the basins with medium extent of cultivation (category II) and for the large rivers.

Until recently the reverse dependence of sediment yield on basin area was considered common for all river basins. However, the direct dependencies are also frequent (Dedkov, Mozzherin, 1984, 1992, 1996; Walling, 1996).

INFLUENCE OF FLUVIAL PROCESSES UPON CHANEL MORPHOLOGY IN THE FLYSCH MOUNTAINS OF EAST SLOVAKIAN OUTER CARPATHIANS

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The territory is situated in the NE part of Slovakia. It is built by the flysch rocks from the Upper Cretaceous and Paleogene. The flysch layers (sandstones alternating with claystones), sandstone layers, in lesser extent also quartzites, breccia and conglomerates, marls, and limestone are represented here. The layers were folded and tectonically dissected. The territory was later uplifted. Erosional and denudational processes recreated the relief to its present form.

Under the effect of relief the rivers draining the territory of flysch mountains acquired an unbalanced long profile. Large basins, longitudinal and transverse erosion-denudational furrows alternate with bulky mountain massifs. Slopes of mountain ranges and of intermountain basins are subject of intensive erosion. Huge valleys and gullies originate here. Streams show a steeps slant. Entering the intermountain basins they accumulate the carried material in debris cones and alluvial fans. They create alluvia of different width in the basins. Accumulation and lateral erosion take place here. In the areas where they break through mountain massifs vertical erosion occurs. Erosion created deep valleys and gorges. The streams often overcome big elevation differences (up to 800 m) on comparatively short sections (20-25 km). Inclination of the streams in their spring parts causes intensive erosion and removal of the flysch weathering material.

The flysch territory were subject to significant changes in recent years. They were provoked by intensive timber extraction and construction of dams and levees. Logging interferes with the stability of the territory and causes the origin of the sheet and linear erosion. The breach of stability of the slopes in turn causes landslides. Construction of water-management works causes changes of the channel-forming processes before and beyond the barrier. They manifested by waves of regressive erosion or accumulation, and caused the present changes of the river channels.

Cognition of the river channels from the viewpoint of their stability, discharge capacity, and of the channel-forming processes is very important for stabilisation of the territory and its rational use.

The resulting forms of the river channels are above all conditioned by the lithological and structural properties of the substratum. Shape of the channel, geological structure, as well as erosional and accumulational elements in the channel enabled the author to distinguish 6 types of river channels.

EFFECTS OF LONG-TERM IRRIGATION ON PHYSICAL-CHEMICAL PROPERTIES OF VERTISOLS FROM THE SUDAN GEZIRA

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The Vertisols of Sudan, comprised of the central clay plain in addition to the southern clay plain and Nuba Mountain clays, are of special importance to the economy of the country as they host most of the important agricultural schemes. This study was undertaken in Gezira, the part of the central clay plains of Sudan that falls between latitudes 13° 30″ and 15° 30″ North and longitudes 32° 30″ and 33° 30″ East. The Gezira scheme constitutes no less than half the total irrigated area, of 1.8 Mha, in Sudan and produces the main cash crop of the country by means of irrigated agriculture. Irrigation has been applied for the last 80 years on these soils.

In the farm of the Agricultural Research Station at Wad Medani a plot was left permanently fallow so that changes in soil properties resulting from soil use could be quantified using this plot as a yardstick. This is particularly important as irrigation water is expected to have modifying effects on soil chemical properties especially with regard to salinity. In this study soil physical and chemical properties of the cropped and non-cropped plots were analysed. Morphological characteristics were also examined in the field in profiles dug at both plots.

The most striking finding in the study is that redistribution of different elements concentration within the soil profile has taken place more clearly in the irrigated plot. Total Ca and Mg were greater in the lower depths of both profiles but greater amounts were found in the permanent fallow plot. In the fallow plot total Na increased with increasing depth in the profile while in the irrigated plot total Na was less at the bottom of profile and least Na quantities were found in the surface horizon clearly reflecting effect of irrigation water in dissolution of Na and changing its zone of accumulation. Potassium was higher in the surface horizon of the irrigated plot indicating effects of silt deposits with irrigation water, which are always high in K content. The exchangeable base cations differed between the two plots as Ca was found to range between 295 to 419 $mMc.kg^{-1}$ in horizons of the permanent fallow while it was 160 to 322 $mMc.kg^{-1}$ in the irrigated plot horizons. Mg, Na and K were 97 to 170, 65 to 281 and 9.1 to 12.9 in the permanent fallow plot as compared to 78 to 95, 10 to 83 and 8.1 to 14 $mMc.kg^{-1}$ in the irrigated plot for the three elements, respectively. The cation exchange capacity of the soils was not affected by the continuous irrigation and it ranged from 585 to 678 and 594 to 682 $mMc.kg^{-1}$ in horizons of permanent fallow and irrigated plots, respectively. The base saturation percentage was significantly greater at the permanent fallow plot reaching values of 68 to 130 % compared to 51 to 75 % in the irrigated plot indicating leaching of soluble anions and cations with irrigation water down the soil profile. This later statement was confirmed when soluble anions and EC were determined. Differences in base saturation found in these soils is explained in terms of changes in quantities of exchangeable bases as affected by leaching, dissolution and perhaps redistribution of bases.

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LAND COVER MAPS: INFORMATION SOURCE OF INVESTIGATION OF SOIL EROSION PROCESSES

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Maps of land cover and those of the objects representing the biophysical substance of landscape constitute an adequate salient point for the study of the contemporary structure of landscape. Analysis of these maps in relation to relief is a standard request for evaluation of spatial and functional relations existing in landscape. The single morphometric characteristics of relief (slopes, lengths of slopes, geometric relief forms, aspects, etc.) in combination with land cover are a suitable source of information for assessment of geodynamic processes ongoing in landscape, such as water and wind soil erosion.

Land cover maps provide the topical picture of the spatial arrangement of morphostructural landscape objects (anthropogenic objects, arable land, forests, grassland, water bodies, etc.) the inner heterogeneity, roughness of surfaces, area, shape and contiguity of which are important for the analysis of soil erosion processes. Possibilities to obtain such information from land cover maps depends on scale and the rate of detailedness of mapping (nomenclature).

The aim of the paper is to provide review of land cover maps created at the Institute of Geography of the SAS and to point at their assets or application possibilities in investigation of soil erosion processes.

IMPACT OF TILLAGE AND MANAGEMENT PRACTICES ON RAINSTORM CONSEQUENCES (CASE STUDY OF LOESS CATCHMENT OF ROZTOCZE REGION IN SOUTH-EASTERN POLAND)

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Field studies were carried out several days after rainstorm, which took place at Tomaszów Roztocze on August 10, 1999. The highest daily sum of precipitation registered nearby reached the level of 63 mm, whereas the estimated maximum precipitation was about 80 mm. Detailed studies on geomorphological effects were conducted in the total area of 50 hectares, in the catchment of dry erosion-denudation valley. Denivelation within the catchment come up 50 m, and 60 % of the area is occupied by slopes of up to 15°. Soil cover of the area is represented by typic Luvisols exhibiting different degree of degradation through the erosion.

Currently the entire catchment is used as an agricultural land. Cereal crops are dominating and cover 80 % of the cultivated area, root crops take over 10 % and permanent grasslands come to 5 %. Fields are divided into narrow parallel strips 15-50 m in width. Direction of fields is random, either parallel or skewed relative to slope. Rills and balks play an important role in the runoff control. These forms are natural channels directing waters to the valley bottom where the water flow becomes concentrated.

Sheet flow and washing were commonly observed during the studied event accompanied by splashing. Rill and channel erosion was only locally observed, while suffosion and evorsion were noticed on scarps. Since studies were conducted after harvest many field were already cultivated using shallow plough or chisel plough. Vulnerability of soil with respect to erosion varied greatly. Small intensity of geomorphological processes was measured on permanent grasslands. A moderate intensity was observed on stubble fields and fields with root crops. The adverse effects of erosion processes were very severe on fields with soils that were mechanically loosen. A dense network of rills had developed at the bottom of slopes. Locally, the entire top soil was removed from the interrill surface. It was calculated that 2-3 cm of top soil was removed from the most eroded fields.

The concentration of water flow at the valley bottom lead to formation of episodic channels. As for slopes the intensity of erosion was dependent on surface conditions. Transport channels had developed in zones protected by vegetative cover. Erosion channels were dominating forms on the loosen soil while on stubble fields erosion-deposition type was more frequent.

Balks perpendicular to the valley bottom promoted accumulation of deluvial fans. The largest fan was formed at the end part of the valley since the flow was blocked by the paved road. However, at the final stage of runoff this fan was partially destroyed.

Number of different geomorphological consequences of heavy rain was identified depending on crops, soil cover, slope, management practices and direction of ploughing. An interesting set of data was collected which may be used for modelling of geomorphological responses to rainstorms.

SEDIMENT SOURCES IN SEMI-ARID WATERSHED

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Concern over sediment problems in semi-arid watersheds has largely focused on sediment sources, sediment transfer through a fluvial system, and the deposition of sediment behind dams. This paper reports on a study of hillslope sediment transport in Nahal Hannon, an intermediate-sized catchment in the Northern Negev Desert, Israel. Primary data were obtained from analyses of radioisotope Cesium-137. Supplementary data were obtained from sediment accumulation behind dams and aerial photo analyses. A 1 000 x 1 000 m grid was sampled in order to estimate sediment transport at the basin scale. To examine the variability of sediment transport over a small area, a 15 x 15 m grid (270 m^2) was sampled in a first-order gently sloping cultivated field in the upper part of the drainage basin. Initial results showed that most of the sediment is contributed from the upper part of the slopes and most of the eroded sediment is stored within the slope system and slowly transmitted downslope to the channel system. Most of the sediment moving along the channel system comes from the channel bed and banks, with little derived from the slopes. The spatial pattern of sediment sources is related to land use, local topography, and distance from the main channel. The sediment yield rate was estimated based on cores taken along a reservoir that was built four years ago. About 30 $tons.y^{-1}.km^{-2}$ of mostly silt and clay size material was deposited, a value that is very low in comparison to other basins in the area.

LANDSLIDE OCCURRENCE AS A RESPONSE TO DRAMATIC LAND USE CHANGE

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Vegetation cover is an important factor influencing landslide occurrence and movement. As a logical consequence, any fluctuations of vegetation cover results in a change of landslide behaviour. This relation seems trivial. It is, however, difficult to assess due to the long periods of anthropogenic influence, in particular true for European countries. Human and natural factors are mostly coupled and it is difficult to relate variations of land use practices to the occurrence of landslides.

Despite these problems, New Zealand provides a unique opportunity to investigate geomorphic responses to land use changes. Before European settlers arrived from 1850s onwards, in particular hilly regions were influenced by human activity only marginal. The Maoris, inhabitants of New Zealand prior to the Europeans, settled in particular in the coastal zones or near lakes and rivers, thus in the plains. They did not influence general vegetation cover. In contrast, European settlers moved into the backcountry and converted large and hilly areas from native forest and bush to pasture, thus reduced the strength of the regolith and consequently made the slopes more susceptible to landslides.

From these unstable slopes, thousands of landslides were triggered with the next high magnitude climatic event. These storms have calculated return periods of 50 or more years. It was shown, however, that storms occurring in different periods but with similar magnitudes have significant differences in sediment production. In these regions, landslides determine sediment production heavily. Thus a broad relation between rainfall magnitude and landslide occurrence could be established and landslide-triggering rainfall thresholds could be derived. However, these thresholds give a broad indication of the probability of landslide occurrence only. They are most sensible to any changes of natural conditions, and in particular to land use modifications.

More generalised national scale analysis of the relation between landslides and vegetation cover suggest, that indeed landslide occurrence is reduced under forest than under pasture. However, the analysis indicates also that if landslides occur under forest, these are less in number but involve much more material. As a consequence it is suggested, that land use change may influence the frequency of landslides - and thus increase public awareness of this process - but it may not change the amount of material supplied by landslides over long time-spans. This suggestion is preliminary indeed and need further justification by more detailed research in the future.

HYDROLOGICAL-GEOMORPHOLOGICAL ASPECTS OF DIFFERENT FARMING PRACTICES

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Slovakia is a textbook example of the territory where in relatively short time distinct changes in farming were accomplished. First of all, it was what is called the collectivisation process, which took place from the beginning of the fifties to the end of the sixties of current century, and in some isolated cases also later. In Slovakia's conditions it is, as a matter of fact, a comparison of land use by prevailingly private owners characterised by small field pattern with collective (co-operative) form of ownership manifest in a pattern of large blocks of agricultural land.

The goal of the paper is an attempt to demonstrate the need to re-evaluate some simplifying views of the influence collectivisation exerted on denudation processes in agricultural landscape, which indiscriminately suggest the increase of intensity of such processes after collectivisation. Single parameters of denudation process controlled by man, relevant to land use patterns in pre- and post-collectivisation periods using evaluations of two model territories were analysed, namely the share of eco-stabilising land use forms, arrangement of line elements and agro-technology.

Results of analysis indicate that after collectivisation changes of numerous parameters, in spite of prevailing estimates, caused the decrease of denudation processes in many places. The share of eco-stabilising forms (forests, permanent grasslands), which reduce the intensity of denudation processes, increased in many cases.

The scope of line elements (furrows between the blocks, field roads) was considerably higher in pre-collectivisation period. Dense and interconnected system of furrows along with older gullies created an ephemeral and efficient system carrying away the soil particles. The effect was multiplied by a dense network of field roads. The mean length of the track of a potential soil particle on its way to some of these line forms to be carried afterwards out of the slope was substantially shorter than the mean track of potential soil particle travelling down a long slope typical for the collectivised pattern of land use.

Evaluation of agro-technology from the viewpoint of susceptibility to denudation process in case of Myjava hill land demonstrated that the direction of tillage (along the contour line or along the gradient line) depended in pre-collectivisation period from orientation of the particular field. Dependence between the direction of tillage and way of farming was not univocally proved. On the other side, the onset and use of heavy agricultural mechanisms after collectivisation caused compactness of mould though simultaneously the depth of tillage increased. This is the way how the retention capacity of the arable layer capable to store the precipitation and to reduce the runoff (and indirectly denudation rate), but only up to saturation of the retention capacity of the tilled layer increased. Then the effect of compact mould and less permeable layer manifests. Evaluation of the obtained results led to the conclusion that the collectivisation process or the way of farming under collectivisation can be in no way one-sidedly and indiscriminately blamed of increased rate of denudation process in comparison with denudation processes in the pre-collectivisation processes. Reliable comparison of the effect of the land use changes on denudation processes calls for individual approach taking into consideration the particular circumstances in each case.

PREDICTING EROSION EVENT IN A SMALL CATCHMENT USING THE ERDEP MODEL AND GIS

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The study presents the dynamic water erosion simulation using the physically-based model ERDEP integrated in GIS. The study area was selected in a small watershed of local brook situated near Mochovce Nuclear Power Station, West Slovakia. Geographically this area belongs to the central part of the Pohronská Pahorkatina loess hillyland.

For simulation the possible short-term effects of single erosion event we have chosen 90-minutes rainfall event from June 16, 1999, recorded by Slovak Hydro-Meteorological Institute, Bratislava. The spatially distributed input parameters for erosion modelling were prepared using ArcView GIS and GRASS. The following three sources of data were used for deriving raster GIS databases (digital model of relief, land cover and soil data): topographic maps, aerial photographs and field survey. Their information content and accuracy represent (where possible) the scale 1:10 000.

The ERDEP model is process-based, dynamic (event-based) water erosion model. It comes out from the unit stream power and physical fields theories and is implemented within GIS GRASS. The overland flow is modelled using 2-D diffusive wave approximation of Saint-Venant partial differential equations based on the finite difference numerical method (r.hydro.CASC2D). The temporal variability in rainfall intensity was modelled using time series of rainfall intensity maps for each 10-minute interval.

The resulting layers revealed changing pattern of erosion-deposition intensities during the event. The total erosion-deposition balance for the whole event was computed by integrating erosion-deposition rates for all modelled time horizons. The different scenarios were computed and compared.

Long-term sediment distribution modelling (e.g. within years or decades) using physically-oriented, event-based models requires detailed information on spatio-temporal variability of every input parameter. Some of them may be estimated using available data sources (maps, reports, aerial photographs). The most important is information on rainfall events with possible erosion effects, as well as land cover changes. However, this approach is rather complicated due to high financial, labour and computational costs.

Some estimates of input data can be done using selected, representative erosion events which must be identified from the analysis of a series of rainfall and land cover data. However the sensitivity analysis of ERDEP shows that detailed information is needed only for land cover changes (to derive Manning's n). Rainfall occurrence, volume and intensity for decades is relatively easy to estimate and results may be still acceptable. Therefore it is possible to model selected periods of time with representative parameter values and then to extrapolate obtained results in time.

POTENTIAL AND ACTUAL WATER EROSION ASSESSMENT IN THE TRNAVA AND NITRA HILLY LANDS

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Negative impacts of water erosion on soil, environment, production and economics are well known. In the paper we would like to contribute to these topics solution with erosion assessment, mainly water erosion, in Slovak Republic, using data of the Soil Information System (SIS). The SIS database includes data on occurrence and the forms of erosion based on Complete Soil Survey (CSS) and revision surveys made within soil bonitation, as well as data necessary for location almost of all factors used for application of runoff losses empirical model calculation, i.e. actual soil damages by erosion in present conditions of farming.

Based on two parameters - textural and sloping data a map of potential water erosion in Slovakia was elaborated in scale 1:500 000. This database and map output however did not fulfil all assessment criteria, mainly modelling soil resources affinity to water erosion. For actual erosion determination, assessment and modelling various approaches are used in the world. To the best known belongs the equation USLE (Universal Soil Loss Equation) for long-term earth loss calculation by Wischmeier, Smith (1978):

$$A = R.K.L.S.C.P$$

The highest mean annual soil loss in $t.ha^{-1}.year^{-1}$ is on Regosols, and eroded Luvisols, Chernozems, respectively. This can be best visible in erosion map under row crops with extreme and strong erosion, again primarily on Regosols and eroded Luvisols Chernozems, less on Rendzinas and Orthic Luvisols. Medium erosion was observed on soils, where occurred primarily Orthic Luvisols and Chernozems. Under cereals was valid the same, with exception of cases with smaller erosion. In the variant with permanent grassland, in all the territory no erosion was registered.

From the spatial point of view larger areas with extreme and strong erosion were found in the Trnava and Nitra hilly lands. Similarly, extreme and strong erosion was registered also on the slopes and valleys in the mountains.

THE INFLUENCE OF AGRICULTURAL LAND USE ON RELIEF DEVELOPMENT OF A SMALL LOESS BASIN

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Research was made on a loess area of an average ground configuration rate, without any natural ravines, not far from Garbów on Lublin Upland (Poland). In September 1995 there was an intensive heavy rainfall here and 50-75 mm of waterfall was recorded, what had significant geomorphological results. A small basin of 20 hectares area was chosen to be an object of detailed analysis, because on such area it was possible to draw up a accurate denudative balance. The analysed basin is characterised by wavy loess relief of comparatively small relative heights reaching 30 metres and slope inclinations up to 10 degrees. Lessivé and brown soils eroded to a different degree, caused by a few centuries of ploughing, occur here.

Agricultural land use changed natural surface flow conditions to a significant degree. Fields belong exclusively to small, family farms and sizes of individual fields amount to 0.2-1.0 hectare. They are limited by a dense net of bulks creating local denudative bases and forming tillage escarpments on slopes of valleys. Flow concentration on ground roads, outflowed and eroded, leads to creating road ravines on slopes and road deluvial causeways in valleys bottoms. These relatively tiny forms diversify the relief.

Significant, geomorphologically important increase of erosion processes occurs while intensive rains or thaws take place. Flow concentration along roads and bulks favours the erosion. A coupling of a few erosion-increasing factors may happen here. Where soil is completely eroded and linear flow is significant, erosion-evorsion potholes 1-3 metres deep are created on bends of incision decrease. These forms are ephemeral. At the same time splashing, rill or channel erosion occurrence on fields is connected mainly to soil condition (vegetation cover or agricultural procedure execution). Excluding some unusual cases, like a road ravine, single lowering of eroded slopes may amount to a few millimetres. However, phenomena of such intensity do not appear often; heavy rainfalls every 40-50 years, while intensive thaws every 10-15 years. Thus, a yearly average intensity of water erosion on ploughed loess slopes does not exceed 1 millimetre.

The condition of soil cover, on some places completely eroded out, may point to much more significant intensity of erosion processes. Measurements of caesium isotope (Cs^{137}) concentration showed that within last 14 years an average interfluve denudation rate reached 0.4-1.2 millimetres, while for watershed humps the rate reached 3.0-4.0 millimetres and for valleys slopes - 4.2-6.5 millimetres per year. These data confirm denudation intensity of ploughed loess slopes measured thanks to pedological and geodetic methods. Thus, the role of agriculturally generated erosion seems to be crucial here. Slopes lowering and valleys bottoms up raising up to 2 metres are geomorphological results of the erosion. It resembles solifluction processes of cold climate results, as it makes relief more gentle.

EROSIONAL PROCESSES AND POND SEDIMENTATION IN A SMALL CATCHMENT, CENTRAL JAPAN

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A small catchment with a pond in Kanazawa, central Japan has been used to reveal hydro-geomorphic changes during the past several decades.

Surface material (soil) in the surrounding catchment was sampled for analysing physical properties (grain size, grain density, and magnetic properties) and chemical properties (Cs-137, etc.). DEM (5 m x 5 m grids in a 1:2 500 map) is introduced to express topography in the catchment. Erodibility of surface layer can be inferred by using Cs-137 concentration; the concentration is low if surface erosion in situ has been proceeding during the past 50 years. Vertical changes in the concentration show that it is low in valley sites while comparatively high in crest sites and slope sites, suggesting higher erodibility in valley sites. These lead to erodible index, $E = (\partial h / \partial x)A$. A is area of catchment.

Pond sediments were obtained for analysing physical properties (grain size, grain density, water content, loss on ignition and magnetic property) and chemical properties (Cs-137, Pb-210, etc.). Analytical results of pond sediments show that there exits a peak in Cs-137 concentration, indicating the year of 1963 and peaks of grain size fluctuations are corresponded to mass movement due to heavy rainfall in 1964. They also suggest that changes in $Pb\text{-}210_{exe}$ concentration are available for age determination.

Average volume of eroded material per year in the catchment during past 30-40 years using the relationship between Cs-137 concentration and erodible index is estimated about 36.1 ton/year with bulk density of 0.8 g/cm^3. Estimated sedimentation rate in the pond over the past 35 years by using some observed sedimentation rate and some assumptions is about 21.1 ton/year. These values suggest that mass balance in this pond-catchment system is given approximately by using some methods employed here.

LAND USE CHANGE, SURFACE AND SUBSURFACE DYNAMICS ON THE DANUBE-TISZA INTERFLUVE

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The objective of the paper is to investigate land use changes on the Danube Tisza Interfluve (Hungary), between 1975-1991 and to analyse possible effects of these changes on surface and soil development as well as to evaluate the changes from different aspects. Changes since 1780 were analysed, too but not in the same detail. Landsat MSS and Landsat TM images from 1975, 1985 and 1991 were used and classified according to the categories defined in the CORINE Land Cover Project.

The study area (56 x 56 km^2) consists of three main types: (1) large fields (2) small fields with mixed land-use (vineyards, orchards, arable land) (3) nature conservation area (national park). The classification of the Landsat images was followed by generating the map of differences between the land use maps of 1975-1985 and 1985-1991 resp. Finally the two generated difference maps were compared resulting a new difference map.

A GIS was then built up, consisting of the interpreted Landsat images, the difference maps, digital elevation model and different thematic maps, i.e. geomorphology, genetic soil types, soil texture, soil thickness, ground water depth and precipitation.

The statistical analysis of land use changes between 1975-1985-1991 was followed by the study of the relationship between the areas with changed land use and the physical-geographical factors.

The change could be followed very well in the case of large fields where a continuous decrease of arable land could be detected. Very little change was found in case of the mixed land use type. The extension of naturally protected areas is defined by law. The effect of re-privatisation after the change of the regime (1989) could not yet be proved. The areas where land use changes have taken place were evaluated from the aspects of ecology, economy and natural protection concerning positive or negative tendencies.

Surface and subsurface dynamics are controlled by ground water level changes. Lakes disappear and reappear again, accompanied by changes in vegetation and soil development of the surrounding area. Moving sand dunes were bound by tree plantations and remobilised again. The above changes were studied in detail in 1:10 000 scale in a test area. There is a significant relationship between land use change and the development of various forms of moving sand.

SLOPE MOVEMENTS IN THE EASTERN MORAVIA (OUTER WESTERN CARPATHIANS)

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Slope movements are the ones of the present-day geomorphological processes in our natural conditions, which transform the landscape relief with the great intensity. Slope movements result in the whole spectrum of slope deformations as depending on the type of the movement. Activation of these gravitational movements is conditioned by geological and climatic conditions, topography and human activities. In our natural conditions, the landslides arise under characteristic meteorological situations such as heavy rains and intensive snow thaw.

The extreme rainfalls in July 1997 (Northern Moravia., Eastern Bohemia), activated mass slope movements particularly in Eastern Moravia (Outer Western Carpathians), this region is built by flysch rocks. The district of Vsetín was one of the most affected by mass movements. The total number of slope failures, activated in the Vsetín district – as documented to the date of December 1999 – amounts to over 500. As to the type of slope movement, landslides together with earthflows and rockfalls seem to prevail. The slope movements (mainly landslides) in some areas considerably disturbed the landscape infrastructure. At some places, the landslides endangered and disturbed peoples' homes, particularly so in the villages of Mikulůvka, Růžďka, individual recreational facilities and entire recreational areas, road and local communications, major railway to the Slovak Republic, local sources of drinking water, telephone cables, electrical supplies, high pressure gas line, forest stands, gardens, orchards and pastures. Mass movements of mountain slopes considerably endangered the water reservoirs of Bystřička, Karolinka and Šance, located in the deep Carpathian valleys. The impact of landsliding had a character of small natural hazards in the some damaged areas.

Great number of landslides has an impact in the cadastral areas of villages Mikulůvka, Růžďka, Malá Bystřice, Bystřička, Velká Lhota as well as in the cadasters of towns of Vsetín and Valašské Meziříčí. The largest activated landslide area in the Outer Flysch Carpathians in Moravia can be found in the valley of Bystřička Brook, locality Vaculov - Sedlo. Length of the landslide area is 4 km, width 1.2 km. There are various types of mass movements, which affect both slope sediments and bedrock. Thick landslide accumulations alternate with water logged depressions (existence of a small lake). Surface and subsurface pseudokarst forms (dolines, fissure caves) developed owing to slope movements in this area. Many lonely houses and special-purpose roads were damaged and particular losses were seen on the soil cover in meadows, pastures and forests.

The activity of mass movements in the Vsetín district is given by the geological control as well as by the character of topography of this dissected mountain Carpathian area. Heavy rainfalls in July 1997 were the main impulse of slope movements. However, each landslide locality has its specific features which, apart from the natural prerequisites, also includes factors caused by human activities. Human impact is an important agent leading to the origin of slope movements in the studied territory. The kinds of human influences relating to development of landslides were investigated. The main human impacts comprise: - building construction on old landslide terrains, - deforestation and pasture conditioning of liquidation of anti-erosion measures, - earth cuts of

roads and railways, - excavation of telephone cables, water supply lines, gas pipes lines and sewer drainage with non-compressed filling, - non-compact slopes of dumps and banquettes.

Special attention will be paid to the mentioned problems during the research project "Geological structures of the territory of Moravia as a conditioning phenomenon of landslide movements" with grant of Ministry of Environment. Within the framework of the Institute of Geonics, Academy of Sciences of Czech Republic, this research is supported by the Grant Agency of the Czech Republic- grant project "Floods, landscape and people in the catchment of Morava River" (grant no. IAA 3086903).

HUMAN INDUCED OVERBANK SEDIMENTATION IN THE VALLEYS OF THE EASTERN SUDETY MTS. FORELAND

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Sudetic tributaries of the Upper Odra river - Opava and Osoblaha/Osobłoga rivers - are characterised by significant floods dynamic caused by high precipitation (1500-2000 mm/year) in headwater area as well as by high gradient of the upper valley sections. The gneisses and Devonian or Carboniferous greywackes and sandstones of Hruby Jesenik Massif (1000-1400 m a.s.l.) and Nisky Jesenik Upland (400-800 m a.s.l.), are the main source of coarse alluvial sediments, which had been deposited since Tertiary on NE the Eastern Sudety foreland. Actually this coarse material is redeposited only during big floods. Fine mineral matter, derived from the Pleistocene slope covers is transported as suspended load. Drainage basins of discussed upper Odra tributaries have been colonised since Neolithic. After migration period marked by the regression of this colonisation, this area began to be settled by Slavonic tribes. This is documented by many archaeological finds and localities. The tribal castles Hradec and Głubczyce among others, existed here at least since the 7th century. The decline of Great Moravia State in the 9th century, was replaced by the Opole Duchy since 12th century. This caused the intensification of agricultural colonisation in the NE Eastern Sudety Mts. foreland. It is documented by numerous settlements, latter towns, noted here during 11th and 12th centuries: Hradec (castle) - 1060, Głubczyce - 1107, Opava - 1195, Głogówek - 1213, Krnov - 1221, and others.

Low-yeld crops of that historical period forced one family to farm one feud of land i.e.15-30 ha. Hence one small village used an extensively large land. It let directly to a deforestation of the fertile soils. As the result, the overland flow of rain and snowmelt water increased soil erosion. High population density, reaching up to 30 person/km^2 on the loessic soils of the Głubczyce Plateau at the first half of the 14th century, inform how extensively these areas were agriculturally used. Every undulated land was exposed to soil erosion. Eroded material had been deposited mainly in the footslope or had infilled the headwater valley floors. A part of them had been transported downstream and deposited in the main valleys floor. Development of the natural levee caused the origin of the backswamps in the middle course of Opava river Osoblaha/Osobłoga valleys. In the middle course of the Osobłoga valley these depressions are filled with non-carbonate silt of 0.05 - 0.002 mm (50-85 %) with significant content of clay < 0.002 mm (up to 30 %). This indicates that the loess cover of the NE Eastern Sudety Mts. foreland was the main source of these deposits. In the lower course of the Osobłoga valley, when prevail the vertical erosion, close to the present channel course there are younger generation of fossil paleomeanders with organic infills, overlain with 2-3 m thick silty overbank deposits. The oldest of these fossil organic infills is dated back to 1120 ± 30 years BP, which indicate to the early medieval intensification of the overbank sedimentation. In the middle course of the Opava valley, downstream Krnov, the valley floor is filled with non-carbonate silty alluvium dominated with 0.05-0.002 mm grain size. These deposits have sporadic intercalations of coarse gravels lenses deposited here during large floods. As a rule, the base of these silty alluvium lies down 2 m below the mean water level in the channel. Simultaneous lack of paleochannels in the valley floor suggests that overbank sedimentation has prevailed there since long time. The loess deposits covering the Opava valley sides as well as fine-grained Pleistocene slope covers are the main source of these fine-grained alluvium has deposited here since at least Great Moravian State expansion.

VALLEY EDGES DISSECTIONS AS AN INDICATOR OF HUMAN INDUCED SLOPE MOBILITY, UPPER SILESIA, POLAND

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At the margin of the Upper Odra Basin, the Upper Silesia, there are patches of loess covers, which has been settled since Neolithic by pastoral and agricultural tribes. The loess area located northward to the Kłodnica valley is covering the carbonate Triassic bedrocks of the cuesta (up to 400 m a.s.l.) and Tertiary-Quaternary deposits of its foreland. This is undulating surface declining southwards to the Kłodnica valley (180-200 m a.s.l.), and dissected by its short tributaries. After considerable reduction of settlements connected with the migration period, the area was sparsely populated during Early Medieval times (Foltyn 1998). The economic expansion of the Opole Duchy since the 13th century caused increase of colonisation in the whole region. The rate of colonisation was so fast that during one century over 20 new settlements were established in this loess covered area in a zone of 8 km wide and 20 km long (Panic 1992). In the middle of 14^{th} century, the density of population reached there 10-16 person/km^2 and up to 30 person/km^2 in the surrounding of the Ujazd area. Extremely low-yelding crops of that historical period forced one family to farm one feud of land i.e.15-30 ha. Hence one small village used an extensively large land. It led directly to a deforestation of fertile soils. As the result, the overland flow of rain and snowmelt water increased soil erosion and gulling.

The Ujazd-Zandrzyny site is l cated at the north right-hand edge of the 1.5-2 km wide the Kłodnica valley. The valley floor is bordered here with meandering undercut of the Pleistocene valley slope, existing since at least from Allorod. The palaeochannel at the foot of this undercut is filled with 4 m thick complex of organic sediments. The lack of significant mineral intercalations indicates a permanent organic matter accretion, initiated at least 10 850±310 years BP, without the valley slope activity. The organic matter accretion was interrupted by an alluvial fan progradation in the mouth of the tributary valley dissecting the edge of the Kłodnica valley. The alluvial fan is built up to 70 % of non-carbonate silts 0.062-0.002 mm with sand (up to 20 %) and clay (up to 10 %) admixture. The Kłodnica valley slope, covered by several metres thick loess deposits was the source area of this alluvium. The alluvial fan prograded gradually, however with short breaks, marked by the increasing of organic matter, and sporadic occurrence of charcoals. Radiocarbon dating of the peat infilling the uppermost part of paleochannel and covered by the fan deposits, 70 m from the slope undercut edge, indicates 780 ± 120 radiocarbon years BP. That informs the beginning of fan development started in the 12^{th} and 13^{th} centuries. The first historical registrations of the neighbouring settlements Ujazd - 1155, Sławęcice - 1146, Zalesie - 1223, Stary Ujazd - 1260, Jaryszów - 1260 and Łany Małe -1292 indicate that growing area of farmlands and simultaneous deforestation of the Kłodnica valley sides were direct reason of soil erosion, valley side dissection and alluvial fan progradation.

CHANGES OF SOIL EROSION CONDITIONS DUE TO AGRICULTURE COLLECTIVIZATION (BLŠANKA RIVER)

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Introduction of large-area socialist farming in the Czech Republic since 1948 and mainly changes in the geometry and the size of cultivated plots with new agrotechnique approaches have created new conditions for water erosion processes. The aim of research was to find a link between the present evident surface manifestation of soil erosion and places of the most negative interventions into the landscape. Situation was observed in detail in the partial catchments of Blšanka basin in the north-western Bohemia. It is mildly undulated agricultural landscape mainly on Perm-Carbon sediments underlayer with fertile brown soils. Growing hop is traditional there.

Changes of erosion conditions were analysed according to four indices: 1. land use changes, 2. prolongation of the length of the plot down the slope, 3. tillage direction changes and 4. soil conservation elements changes. Aerial photographs from the years 1938 and 1987 were used. Field measurements and mapping followed.

Socialist farming generally did not induce land use changes in the sense forest x arable land x grasslands. Great increase was registered in the area of hopgardens. Hop belongs to the crops least resistant to soil erosion, mainly when rows are situated down the slope (up to 80 % of cases). One third of the present plots have arisen by unification of three to five former fields, 25 % more six former fields (in extreme 15 fields). Half of fields were unified exclusively in direction down the slope. The transformation has caused a lot of changes in line anti-erosion elements. Nearly a half of protective vegetation belts or balks have disappeared. Collectivisation changed also the way of tillage: in a half of cases the initial direction has been maintained, in the second half the tillage down the slope was preferred. On the base of findings on the landscape transformation present erosion forms were mapped. Most frequently they were rill erosion and accompanying accumulations that were quite wiped off by repeated ploughing. More than 200 years old gully system has been also partly activated. Field research was backed by occasional measurements and also by calculation of material lost according to USLE. While in 1938 erosion mostly affected plots in more inclined position of the catchment area (quite exceptionally above 10 t/ha/year, mostly acceptable erosion limit was not exceeded), at present, the problem of erosion was found in slightly inclined plots with a great uninterrupted length in direction down the slope (up to 1.5 km), on which maize or hop are grown (frequently even more than 25 t/ha/year).

IMPACT OF EARLY AGRICULTURE ON THE ALLUVIUM IN THE SAN RIVER HEADWATERS (POLISH EAST CARPATHIANS)

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The sediments in the youngest alluvial terrace (1-3 m above channel bottom) in the headwater course of the San river is distinctly bipartite with the older gravels overlaid by recent muds. This papers explores the possibility that the change in the nature of the young alluvium is related to deforestation and introduction of agriculture by early settlers. The older, Pleistocene and older Holocene alluvium in the San valley is mostly composed of gravel. The lower layer, up to 0.5 m thick, is composed of gravel and overlain by mud 0.5-2.5 m thick. The boundary between the two layers is sharp and marked by a rich accumulation of wood debris at the base of the mud.

The wood debris includes mainly fragments of branches, bark, roots and trunks. Less abundant are leaves, seeds and fruits. The wood debris is accompanied by subordinate fragments of peat and fungi. The coarser material lies mainly at the base, where it forms a continuous layer or mixed, organic-mineral lenses up to 40 cm maximum thickness. Single coarse tree trunks are also buried in topmost part of gravels. Some trunks have traces of being worked by humans. The mud includes also charcoal as coarse fragments and dust. Radiocarbon dates of the wood debris in the basal part of the mud range from 500± 65 BP to 230± 60 BP, while the dates from leaves accumulated in the artificial basins cut in the alluvial mud of the youngest terrace range from 250± 120 BP to 150± 120 BP. These dates indicate that the wood debris was deposited during the second half of the second millennium.

The historical data on the human settlement indicate that permanent settlement and farming began in the Bieszczady mountains after 1500 AD and during one century it reached the headwaters of the San. The valley became largely deforested and large areas were turned into ploughed fields. The change in the nature of the alluvial deposits is roughly synchronous with the major phase of settlement and deforestation and it was likely caused by the change in land utilisation. The wood debris and charcoal are the expected result of forest clearing by fire. The exposure of vast areas of land and the beginning of its regular ploughing may be responsible for accelerated soil erosion and accumulation of the muddy floodplain in the valley bottoms. After depopulation of the area in the middle of the 20th century and the cease of farming, the accumulation of the mud terminated, the former floodplain is no more being flooded and the rivers intensely deepen their channels into the flysch basement.

CHANNEL INCISION AND FLOW INCREASE OF THE UPPER WISŁOKA RIVER, SOUTHERN POLAND, SUBSEQUENT TO THE REAFFORESTATION OF ITS CATCHMENT

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Geomorphological literature abounds with papers describing processes induced by an increasing human impact on the environment but studies of the reverse trend are rare and limited mostly to small, experimental watersheds. Depopulation of the Eastern part of the Polish Carpathians in the late 1940s and its subsequent reafforestation have provided an opportunity to investigate the influence of these changes on fluvial processes in the catchments several hundred km^2 in area. In the upper Wisłoka River catchment, the forest cover increased from 26 % in 1900 to 30 % in 1938 and to 67 % in 1990. The forests have expanded on the middle and lower parts of slopes, which previously were cultivated or used as pasture. The depopulation has also limited other forms of rural activity; cart tracks have been abandoned and become progressively overgrown with bushes, timber harvesting has been reduced and undergrowth in the forests has stopped to be used for grazing.

These changes must have led to a significant reduction of sediment delivery to the stream channels. The deficiency of sediment available for fluvial transport became pronounced with the occurrence of increased precipitation and high flood flows in the years 1965-1980. It resulted in a deep incision of the upper Wisłoka channel, reflected in a rapid fall of the minimum annual stages of the river at the Żółków gauging station by 1.7 m between 1965 and 1981, followed by their slow lowering afterwards. In some reaches the river has incised to bedrock. The downcutting has been associated with a significant change in channel geometry. With the channel width decreased from 60 to 24.6 m and the depth increased from 1.85 to 3.16 m, the width/depth ratio of the channel at Żółków diminished from 32.4 in 1963 to 7.8 in 1991, testifying to the transformation of the river from a bedload into a suspended load stream. In the years 1970-1991 a flow capacity of the new, narrow channel increased from 33 to 112 m^3/s. A progressive concentration of flood flows in the river cross-section with the advancing incision has resulted in the transformation of a former floodplain into a terrace while a new, narrow floodplain has developed on parts of the previous, wide channel bed.

A considerable increase in water run-off from the upper Wisłoka catchment has been recorded since 1965. This increase could only partly be explained by the increased precipitation in the years 1965-1980 but afterwards it continued despite a decrease in precipitation. So far, no satisfactory explanation for this „excessive" run-off has been proposed. A synchronous commencement of the channel incision and the run-off increase indicates a linkage between both phenomena. We relate the increase to the lowering of water table in the river with the progress of incision that has steepened a hydraulic gradient across the valley floor. It has caused water previously transferred downvalley through highly permeable, coarse-grained alluvium to be drained off into the channel. Thus, the „excessive" increase in run-off from the catchment is an artefact of recording presently at the gauging section water that prior to the incision was flowing underground within the valley floor gravels.

PROJECTION OF CLIMATE CHANGES, VARIATIONS IN LAND USE AND URBAN DEVELOPMENT OF THE DRAINAGE BASIN IN THE CONTEMPORARY TRENDS IN THE TRANSPORT OF THE SUSPENDED MATERIAL IN THE VISTULA RIVER (POLAND)

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The rates of the transport of the suspended material considerably exceeds that of the bottom transport in the mountain and uplandic tributaries to the Vistula River. In the river these values are close to each other and in the lower stretch of the river the bottom transport even predominates. The suspended material after 1946 is regularly measured in a large number of gauging stations by the State Hydrological Service. Differentiation of the average outflow of the suspended material from the drainage basin of the tributaries, presented in tons/km^2/yr makes it possible to find the relative differences in the extent of erosion. On the other hand, the changes of the material transport proceeding over many years are caused by climatic factors, variations in land use, regulation works on rivers, construction and operation of water dams, inflow of industrial effluent.

Application of the calculation procedure, modified in respect to the standard procedure made it possible to obtain a series of an annual transport values for each measuring station, under the minimal estimation error. The annual transport values over 50 years (1946-1995) were analysed and compared with the longer series of the outflow. The obtained results lead to much more precise evaluation of trends in the transport changes, related to the outflow value than in the earlier works of the present author. It was also possible to define the role of isolated natural and anthropogenic factors in the long-term changes of the rates of transport in the whole course of the Vistula River and its tributaries.

The predominant effect of the water dams and river regulation on variations of the transport of clastic material in the whole course of the Vistula River was established. The influence of changes in the use of land in the Carpathians is not significant in the main river and changes caused by increase or reduction of inflow of raw sewage are of local impact only. The trends in the transport of the suspended material in the course of the whole Vistula River, similarly as in the Carpathian tributaries are generally independent of the long-term hydroclimatic fluctuations. The usually underestimated role of river regulation in the increase of material transport and in the subsequent decrease of the material transport was duly emphasised in the present work.

The calculated statistical relationships between the compared values and the mathematically proved tendencies of the transport changes are used as the basis for the prognosis regarding the transport of the suspended material in the whole course of the Vistula River.

A FREQUENCY ANALYSIS OF PHASES OF COLLUVIATION IN THE LOESS HILLS OF SOUTH GERMANY BASED ON OPTICAL DATING

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Geomorphic response to anthropogenic land use changes in south Germany is documented in soil erosion derived colluvial sediments. Dating of such sediments is usually based on artefacts and ^{14}C dating of organic remains. However, the ages of objects incorporated in colluvium usually provide maximum ages only for the time of sedimentation because reworking of such objects occurs frequently. During the last few years the development of optically-stimulated-luminescence dating (OSL- or optical dating) has led to the possibility of accurately determining the time of deposition of colluvial sediments.

Results will be presented of optical dating of soil erosion derived sediments from South Germany. More than 60 ages were obtained from several different sites in the loess hills. For methodological reasons, sampling was restricted to sediments from below 50 cm depth. Therefore, the last 200 years were not included in the analysis. For statistical analysis, Gaussian curves were calculated from each datum. The individual curves were then summed and the resulting distribution analysed. Unfortunately, such an analysis is of limited value because only the number of ages is used for analysis, and volumes of sediment deposited are not considered.

Nevertheless, phases of colluviation clearly coincide with phases of strong human impact: First colluvial sediments were deposited during early Neolithic times. A second small maximum in the distribution occurs toward the end of the Neolithic period. Many colluvia originate in the Iron Age and Roman periods, while the maximum number of optical ages relate to Medieval times.

This clearly shows that colluviation is dominated by changes in land use practices and intensity. Climatic fluctuations seem to be of minor importance only.

PEDOGEOMORPHIC RESPONSE TO SHORT-TERM GEOMORPHIC PROCESSES OPERATION AS THE CONSEQUENCE OF COLLECTIVIZATION IN AGRICULTURE

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Landforms range in size from the tiny impact craters of raindrops to continental shields. The larger the landform, the longer is usually remains in existence. The duration of its existence, in turn, will have considerable influence upon the kind and the number of changes to which it is subjected during its development. There are two basically different kinds of landform changes. First **eksystemic** kind of landform changes is generated from outside the operating geomorphic system. We assume that at background of those geomorphic changes there is the system of stable equilibrium. The second **ensystemic** ones, are those that originate within the operating geomorphic system, without change of external factors of that system. Land use changes are the most important ensystemic changes influencing operation of geomorphic processes. They caused several relatively young changes of landforms development. Geomorphic systems are in the **metastable equilibrium** and land use changes acquire the nature of **fluctuation.** Each period of land use can be expressed by relationships between short-term processes and long-term trend development and simultaneously between small ephemeral forms and large more resistant ones. Large, slowly changing forms create some kinds of background for the small ephemeral forms. The evolution of large landforms is interpreted in earth-historical time. For study of short-term processes and forms that is physical time, the variable *t* is essential component for all processes. Each time period of the particular spatial operation of geomorphic processes under particular land use on geomorphic background is the **phase of fluctuation** of geomorphic system. One of phases of geomorphic processes operation is their operation caused by **collectivization** in agriculture. Collectivization has erased previous pattern of land use. Small plots were joint into large co-operative fields. Climatic events combined with the contemporary land use pattern caused local geomorphic ephemeral and short-term processes. Material movement is spatially differentiated. Some areas are untouched. In other places processes and forms are organised into open, closed and pulsing **catenas**. For the purpose of differing pedogeomorphic response of short-term processes during the large-scale land use in **Jablonka catchment caesium-137,** so called **"pedogeomorphic"** and **dendrogeomorphic** approaches have been applied. On the basis of interpretation of the activity of caesium-137 in soil of 10 localities along five pulsing catenas in the Kostolné subcatchment we established that the rate of soil accumulation in the outlet of subcatchment is approximately 0.8 cm/year (30-35 cm/35 years). By means of so called "pedogeomorphic" investigations we investigated the accumulated soil layer by knowing the age of fence posts (locality u Otiepkov), a buried telephone pole (locality Luskovica), or by analysing of soil profile (localities Luskovica, Paprad, u Hučkov). On the basis of obtained results we approximately determined that the rate of soil accumulation is about 2-4 cm/year in this above mentioned type of landscape. Dendrogeomorphic investigation has been applied in 6 landscape types i. e. 3 localities in the flood plain of Rudník stream (upper, middle and lowest part), 1 in the bottom of dell and gully and 1 in colluvial fan. The average rates of sedimentation in the upper part of stream is 1.3 mm/y, middle part 2.8 mm/y and the lowest one 0.5 mm/y. The bottom of dell is filling by velocity around 1.3 mm/y, the bottom of gully 4.4 mm/y and the rate of soil accumulation in the colluvial fan 2.9 mm/y.

GEOMORPHIC RESPONSES TO LONG-TERM LAND USE CHANGES (NEOLITHIC TO OTTOMAN PERIOD) IN EASTERN MACEDONIA (GREECE)

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For about 30 years, there has been numerous studies on the Holocene morphogenesis in Greece but little work has been conducted in Eastern Macedonia. The basin of Drama, encased in the Rhodope, offers the opportunity to understand the geomorphic responses to long-term land use changes at the hinge of the Mediterranean area and the Balkan.

The aim of this research was to determine the succession of periods of soil erosion, stream agradation and morphogenic stability and the role of the physical and anthropogenic processes in the destabilisation of the morphogenic system. Field and laboratory work, image analyses and geochronological data (radiocarbon and archaeological datations) have allowed to determine the Holocene chronostratigraphy. To understand the land use changes since the Neolithic, geoarchaeological studies have been carried out understanding of the agricultural practices, thanks to archaeological and historical researches, and analysing of the settlement's environmental features made it possible to estimate the extent and the intensity of the land use at different periods since the Late Neolithic (5300 to 3200 BC).

In the centre of the Drama's basin, since the arrival of the first farmers (Late Neolithic), the alluvial agradation is 1 to 4 metres thick. A moderate erosion took place during the Bronze Age (3200 to 1000 BC), but the real destabilisation of the soils had begun later. Two morphogenic crises have been identified the first took place during the Antiquity and the beginning of the Byzantine era (3rd century BC-7th AD), but at different times in each drainage basin, the second, more important and widespread, during the Ottoman period (from 15th to the beginning of the 20th century AD). Despite early settlement no major erosion crisis was noticeable before the Antiquity. So, it appears that the destabilisation of the soils happened later in Eastern Macedonia than in many regions of Greece.

During the Neolithic and Early Bronze Age, the morphogenic stability is explained by land use pattern. In fact, it appears that the farmers cultivated mainly the soils with good textural and structural stability located in the lower part of the different drainage basin. The shifting of the settlement to the foothills and the lower slopes during the Late Bronze Age probably explains the first trace of soil erosion. After the Antiquity, the land started to become much more used making the morphogenic system less resilient. The two historical erosion crises are clearly linked to land use changes and particularly with the upstream progression of cropping and grazing. However, the importance of avulsions and the increase of the size of sediment transported, for example, also suggest notable hydro-climatic changes (particularly during Little Ice Age). Thus, the destabilisation of the Holocene soil-landscape system in Eastern Macedonia results probably from the conjunction of climatic and land use changes.

Finally, the research shows the complexity of the geomorphic responses to land use changes at the scale of a medium size drainage basin (3000 km^2) several examples underline the role of the scale analysis, of the morphogenic's threshold and morphostructural context in the rate of alluviation, and the relay phenomena between the slope erosion and the floodplain agradation.

CHANNEL RESPONSE TO LAND USE CHANGES IN MOUNTAIN STREAMS OF THE SOUTHERN FRENCH PREALPS

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The southern French Prealps are submediterranean mountains characterised by a strong vegetation development on hillslopes since the beginning of the 20th century. Forest and shrub covers have strongly increased to the detriment of agricultural areas. These changes are induced mainly by the agricultural decline, which has taken place from the beginning of the 20th century, and secondarily by the reafforestation programme of the French State, which was operating between 1860 and 1950. During the same period, mountain streams show a strong active channel narrowing associated with channel degradation and pavement development. Nevertheless, we observe an important regional variability in the intensity of channel changes. Our objective is to analyse the nature of the channel response to the different intensity of land-use changes that we observed in this area and to assess the respective influence of planned and spontaneous vegetation development on active bed extinction.

Fifty one sub-watersheds of 10 to 100 km² were selected in the basins of the three main rivers of these mountains (Drôme, Eygues and Roubion rivers) in order to characterise the regional variability of active channel changes. For each sub-watershed main alluvial reaches were selected in order to measure active channel area on three sets of aerial photographs (1948, 1971 and 1991-96). Land-use changes were investigated using different archives and documents: the Napoleonian Cadastre (1820-1840), the agricultural survey of 1954 and the CORINE Land Cover database of 1993. These documents allow to determine the relative surface occupied by main land-use types at different periods for each administrative elementary unit of the 3 studied basins.

This study allows us to determine the relative importance of land-use changes induced by planned reafforestation in comparison with those controlled by spontaneous growth of forest and shrub cover following agricultural decline. It has been shown that contemporary land use changes were essentially controlled by the spontaneous vegetation development. Historical channel changes (since 1948) are significantly related to forest and shrub development on hillslopes, even if land use changes don't explain all the variability of channel response observed. These results get us to think that active channel adjustment is also highly controlled by the recent flood history which has induced the progressive stabilisation of active channels by pioneer alluvial vegetation. We also show that the recent active channel narrowing is not related to torrent control works (check-dams, dredging) which were done between 1860 and 1920. Channel adjustment to these human disturbances was probably achieved during the 1950s.

MAN-MADE TERRACES IN CAUCASIA AS TRASFORMERS AND STABILIZERS OF MOUNTAIN SLOPES

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As a rule, the human economic activities in general and in mountain regions in particular produce a negative impact to natural processes and thus call for a remedy actions for destructive man-borne meddling. One of the few examples of the favourable influence of human activities to development of a natural processes is presented by a man-made terracing of mountain slopes.

In the Caucasia the slope terracing first appeared in the 10^{th} to 12^{th} centuries and then was developed in the Middle Ages, i.e. during the great migration of nations. Millions of Oriental people were moving along the Caspian shoreline and through the Caucasian mountain passes to Europe, sweeping off indigenous population and driving the remains of it deep into mountainous areas with no land for cultivation in that time. A need to use valley slopes has arisen. Terracing them could only solve this problem. This kind of human activities has been developed especially in the Eastern Caucasia (Dagestan and neighbouring areas), where artificial terraces have been created on very steep slopes (up to 70°).

As a terrace base any slope irregularities could be used. To cover bare slopes the soil has been carried and unloaded on them, and then levelled. On loose downslope aprons the 1-2 m-high masonry retaining walls have been erected and the rear has been filled with soil. The terraces have been arranged in staggered rows. Sometimes the retaining walls were reinforced by planting trees along them.

The terraces have been developed over the entire slope, catching almost all surface water run-off, dividing it into small parts and transferring it into the underground run-off. The humus washed out from the non-terraced slopes has been accumulated on the terraces. In the alpine-meadow zone the humus cover is 0.5-1.0 m in thickness. As a result the purely natural system has been converted into a natural-technogenic one. The slope erosion ceased to develop. The slope processes have gradually decreased in intensity and became a feature of local, discontinuous manifestation. In such a way, the slope run-off was trapped and didn't reach the valley bottoms. The slopes' status has changed from being highly dynamic to a stabilised one.

FRACTAL DIMENSION AS THE INDICATOR OF SUSCEPTIBILITY ASSESSMENT FOR LANDSLIDE IN NORTH MATSUURA-NAGASAKI.

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Fractal dimension as the indicator of similarity, density, complexity, frequency seems to be useful to analyse susceptibility assessment, distribution pattern and also can be use as comparable factor.

To indicate the spatial distribution of the shallow landslides quantitatively, their fractal dimensions and probabilities were estimated on landslide area northerly from Nagasaki in Japan. The region consists of Early and Late Miocene and Holocene rocks.

In order to calculate fractal dimension, capacity and information dimensions were selected. Landslides were grouped on the basis of surface geometry analysis and geology of the study area. The procedures resulted in six groups from elevation and slope points of view, in four groups from geometric form and aspect points of view and in three from geology point of view. In each landslide group, fractal dimension was calculated. The fractal dimension ranged from 0.79 to 1.52 in the case of the capacity dimension and from 0.76 to 1.50 in the case of information one. The value of the fractal dimension reflects the similarity, density, complexity and frequency of the landslide distribution. Values of the fractal dimension 1 and 2 are corresponded with linear pattern and homogenous areal pattern respectively. So, the fractal dimension around 1.5 looks as the most dangerous, due to its chaotic and heterogeneous distribution. The probability of the occurrence landslides in an individual landslide group was calculated on the basis of the relationship between ratio of the average landslide area and area of the landslide group and fractal dimension. By this method the highest potentiality was calculated in the landslide group of the Early Miocene rocks.

INFLUENCE OF MAN'S ACTIVITY ON THE DEVELOPMENT OF LANDSLIDES IN SLOVAKIA

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The landslides are an important factor in geological endangering of environment in Slovakia. The present regional investigation has registered in Slovakia more then 15 000 old potential landslides, which cover an area of about 1 620 km^2. The landslides are concentrated in the flysch highlands, intramountain basins and on the margins of young volcanic mountains. The landslides damage the forests, the arable soils, meadows and pastures. They endanger railways and roads in 1300 sectors. They limit extension of towns and villages into unstable surrounding. The slope stability is a limiting factor in an optimum landscape use. About 90 % of new landslides take place by reactivization of potential landslides due to man's negative intervention.

Anthropogeneous interventions act on the stability of old, dormant landslides differcubly. The landslides are either artificially loaded or undercut. Man's activity induces changes in the regime of groundwaters or causes dynamic effects on the landslides. The lecture will analyse cases of activation old landslides due to the construction of civil or industrial structures, bridges, roads, tunnels, pipe-lines and water artificial reservoirs. Numerous landslides were induced by deforestation of land, incorrect agricultural melioration works, worsening of flow - off surface and underground waters and failures of the underground pipe-lines.

The high number of artificially activated dormant landslides in the areas with an intense economic activity in Slovakia is alarming. With the constantly increasing urbanisation of Slovakia, it can be expected that this trend will be maintained even in the future, if we do not learn a lesson from the committed mistakes.

Man's activity in densely populated areas is becoming the most important geological factor. By its influence is activating the landslides of bigger dimensions, which are usually causing the, biggest damages. From these findings, however, results the fact that the risk of renewing movements of old landslides may be decreased to the minimum, when we know the degree of danger, which threatens all the planned and existing structures in the sliding areas.

Prevention is of important significance for ensuring the stability of affected slopes. The preventive works are simple, cheap and exceptionally effective. From the analyses of expenses for preventive stabilisation works in the road network of Slovakia it results that they are 5 to 10 times cheaper than those for consequent correction works made on occurred landslides, not mentioning all the direct and indirect damages, which each landslide may cause.

In order to avoid devastation of the environment and extensive material damage, special analytical engineering geological maps of slope deformations are prepared for the construction of greater units. These maps are prepared by engineering geologists specialised in mapping slope deformations.

Engineering geological documents containing maps of slope deformations make possible the use unstable areas for urban development. Influence of large scale and local land use changes on transformation of spatial distribution, nature of operation and intensification of past and actual geomorphic processes, namely shallow mass movements is the subject of this paper.

DELINEATION EROSION RESPONSE UNITS (ERU'S) AS MODELLING ENTITIES FOR RIVER BASIN EROSION STUDIES AND THEIR APPLICATION IN THE REGIONALIZATION OF EROSION PROCESSES

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Within an interdisciplinary EU-funded Project aimed at developing an **Integrated Water Resources Management System (IWRMS)** for water resources analyses and prognostic scenario planning in semiarid catchments of Southern Africa, a study regarding the delineation of soil erosion processes in the Mkomazi-river catchment (Kwazulu/Natal- South Africa) and the Mbuluzi-river catchment (Swaziland) has been carried out. One of the objectives of *IWRMS* is to enable managers and decision makers to improve regional strategic planning of catchment water resources by optimising water use, thus satisfying the demands of competing stakeholders while protecting water and land resources. In this more general framework a specific study on sediment source area identification has been carried out. For this purpose the concept of Erosion Response Units (ERU's) has been developed and applied. The ERU's are defined as: *„three- dimensional distributed terrain entities which are heterogeneously structured and having a common climate, land use and underlying pedo-topo-geological structure, which are controlling their erosion dynamics*". ERU's have the vantage that they can be used for spatial scale transfer in regional erosion modelling because of preserving their properties. To describe the sediment budget in a river basin besides the soil loss by sheet erosion also the soil loss due to gully erosion has to be known. In this study the ERU's are used to identify source areas of different erosion processes and as modelling entities for erosion simulations. Further the ERU's have been applied in the regionalisation to get information about the whole river basin susceptibility to erosion. The input data was obtained by remote sensing techniques (API method) and GIS-analyses. Model validation and verification have been done by using detailed information of time series analyses of the terrain morphology and a ground truthing campaign conducted in November 1998. The two examples from southern Africa show that the applied methods are able to individuate areas affected by rill- interrill erosion. Furthermore it is possible to estimate the amount of soil loss due to rill- interrill erosion processes for characteristic subcatchments and to regionalise this information.

THE EFFECTS OF CHANGING LAND USE ON SEDIMENT SOURCES AND RATES OF OVERBANK SEDIMENTATION IN THE CATCHMENT OF THE RIVER TWEED, SCOTLAND, OVER THE LAST 100 YEARS

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The River Tweed in Scotland drains an agricultural catchment (4 390 km^2), which ranges from moorland and rough grazing in the headwaters, through pasture in intermediate areas, to cultivated land in the lowlands. Over the last 100 years there have been marked changes in land use and management in the catchment. Cores collected from overbank deposits have been used to reconstruct recent historical changes in suspended sediment sources and rates of overbank sedimentation at three sites in the Tweed catchment. Unsupported ^{210}Pb and ^{137}Cs have been used to derive a chronology for the cores, and to determine rates of overbank sedimentation over the last ca. 32 and 100 years, respectively. Composite fingerprints and a numerical mixing model have been used to establish down-core, and thus temporal, changes in sediment sources. Results show that there have been marked changes in both rates of overbank sedimentation and sediment sources over the last ca. 100 years. In particular, the relative contributions from uncultivated topsoil, cultivated topsoil and channel bank sources have changed. These changes appear to coincide with changes in land use and management within the basin, although there have also been changes in precipitation and river flow. The results suggest that future changes in land use are likely to influence the sources of fine-grained sediment transported by the river and rates of overbank sedimentation on the floodplain.

THE RELATION BETWEEN PREHISTORICAL SETTLEMENT AND RELIEF IN THE POLISH CARPATHIAN FOOTHILLS

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The Polish Carpathian Foothills are featuring typical agricultural landscape. The geographical environment of study area (the Carpathian Foothills between the Raba and Uszwica rivers - 150 km^2) was shaped by natural evolution and the anthropogenic pressure initiated during the Neolithic period.

This paper shows the proposal of use of GIS to analyse relation between prehistorical settlement pattern and relief. Based on archaeological materials, which describe 400 sites of prehistorical settlement from different periods, 4 maps were prepared. The whole analysis was based on prehistorical settlement maps, the elevation map (DEM), map of the main relief features, the map of slope aspect, the map of slope inclination and the map of river equidistances. The analyses of the maps were made with the use of IDRISI GIS-package.

The first part of the paper overviews the influence of natural conditions on the development of settlement. In this part it is also presented the method of assigning the areas which were influenced by economic activity. It was found that prehistoric man preferred settlement location on hill-tops, on E exposed slopes with small inclination (0 - 4^0) and avoided valley floors. The number and spatial distribution of all preserved prehistoric sites proves that the intensity of morphodynamic processes is still small, even though the area has been used for agricultural purposes since Neolithic period.

In the second part of the paper the geological profile is presented to find the reflection of human activity in sediments. OSL, TL and ^{14}C dating methods have been applied to analyse the sequence of silty sediments deposited on alluvial fan situated at the outlet of a small foothill valley. The results document the redeposition processes during the Holocene phases of enhanced morphogenetic activity, which were conditioned by either climatic changes or the human activity (during the Neolithic, Roman period and early Middle Ages).

The relation between prehistorical settlement and relief evolution in the Carpathian Foothills is interesting from regional point of view. In the Carpathian Foreland Uplands (North of the Carpathian Foothills) there were found "places of Neolithic catastrophe" due to high pressure prehistoric human activity of local nature. High intensity of morphodynamic processes due to deforestation, location of arable fields and grazing areas was documented in the Beskidy Mountains (South of the Carpathian Foothills).

The Carpathian Foothills, situated between the Carpathian Foreland Uplands and the Beskidy Mountains, reflect different agricultural practices that are adapted to relief and spatial distribution of landforms, since Neolithic period up to date. This conclusion is in agreement with the results of research carried out at Research Field Station at Lazy (Jagiellonian University, Institute of Geography) situated in the Carpathian Foothills.

CHANNEL CHANGES AND DYNAMICS OF THE PRE-CHANNELIZED DANUBE IN BRATISLAVA (1712 - 1886)

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Data from old maps help us better understanding nature and operation of the fluvial processes in the past. They can significantly contribute to differentiate effects of such synergically operating factors as hydroclimatic fluctuations, anthropically accelerated larger-scale erosion - accumulation processes in the river basin or local anthropic impacts into the water regime.

Based on historical maps, Danube channel changes and development were reconstructed from 1712 on. Studied area comprises the territory of present Bratislava - the capital of Slovakia, namely 14 river kilometers (rkm. 1861 - 1875) on the Middle Danube. Channel pattern, basic types of its changes and dynamics of pre-channelization period (to 1886) were identified. Mean rates of lateral erosion on outer banks of the mainstream curves reached 9 - 12 (up to 17) metres annually, in the subsystem of Malý Dunaj Arm 1 - 3 m, respectively. In 4 cases, sudden changes of the mainstream occured during development of the curves (by radius of 1100 - 1300 m), when new river bed was formed and stabilised itself in a middle-and high-flow spillways direction. On the calmer reaches, stream curves could evolve up to meander degree (4 meander cut-offs were documented). Anthropic impact was represented by filling-up of field depressions (= forming a quay), bank erosion control measures, sedimentation control of arms being abandoned, construction of line structures - new banks and flood control dykes (1773 - 1776 in Petržalka subdistrict). Effect of major floods and hydroclimatic fluctuations was studied, too.

RECONSTRUCTING GEOMORPHIC RESPONSES TO LATE HOLOCENE LAND USE CHANGES

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The principal geomorphic response to anthropogenic land use changes has been the production and redistribution of large amounts of sediment. While the processes of entrainment, transport and deposition of sediments are themselves generally well understood, understanding of the overall geomorphic response requires characterisation of the affected system, i.e. the system of sediment redistribution. A conceptual approach to elucidation of such systematic behaviour is presented.

In combination with dating techniques, stratigraphic interpretation allows reconstruction of the chronological development of late Holocene (and older) landforms. More specifically, it is possible to reconstruct the chronological development of small scale landscape elements. Relation of the histories of these elements to each other in a spatial context, as components in a cascading system of sediment redistribution, allows reconstruction of geomorphic responses to change at the landscape scale.

A range of methods can be used to derive information on spatial extent, magnitude and rates of sedimentary redistribution for different periods. Rates of sediment redistribution over recent decades can be derived with use of ^{137}Cs and ^{134}Cs, an approach that is specifically spatially focused. Over longer periods, information on deposition rates can be derived from ^{14}C and optical dating, pollen analysis, and geochemical techniques among others.

With sufficient data, movement of sediment pulses through the cascade system can be reconstructed, and the timing and nature of geomorphic responses to human land use changes can be identified. Contemporary behaviour of the sediment redistribution system can thus be placed in an historical context. Specifically, it should be possible to determine the degree to which the response has already advanced, and to characterise the system in terms of its proximity to an equilibrium condition. Importantly, inferences can be drawn with respect to likely future behaviour and sensitivity of the system under various scenarios.

ANTHROPOGENIC IMPACTS ON MORPHODYNAMIC OF HIGH-MOUNTAIN SLOPES IN THE TATRA MOUNTAINS

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The research was done in the Kasprowy Wierch area, and are particularly concentrated with the Kocioł Gąsienicowy valley where summer and winter tourism exert a strong influence, and with the Kocioł Goryczkowy Świński valley which is closed to tourist. Both areas are characterised by granite bedrock and a location within the subalpine and alpine altitudinal zones. Present-day modelling of slopes was taken into consideration based on geomorphological mapping in scale 1:1 000 and three years measurements of intensity geomorphological processes as well as historical data.

Both Kocioł Gąsienicowy and Kocioł Goryczkowy Świński have mature relief and are quite stable. Only of the small fragments of slopes occupied by erosional niches and fresh accumulation in the form of alluvial cones are their indicators of the contemporary activeness of processes. The upper part of slopes are dominated by periglacial processes, mainly solifluction while soil and debris creep prevails on the remaining parts. Both now and in the past, the greatest role in the modelling of slopes - manifested in appearance of new forms -has been that played by processes linked to the flow of water down slopes. These are now processes of slopewash and linear erosion, in the past debris flow. The majority of debris flows gullies and levees are at present inactive and stabilised by vegetation.

Despite the similarities, the relief of the two areas is characterised by rather differing morphodynamics. Attesting to this is, *inter alia*, an area of fresh erosional forms three times as large in Kocioł Gąsienicowy as in Kocioł Goryczkowy Świński. Slopes in Kocioł Goryczkowy Świński are stabilised to a considerably greater extent, while the vegetation on the sides of the eroded channels constitute a more advanced stage of succession than that in analogous habitats in Kocioł Gąsienicowy. The causes of these differences can probably be sought among data for tourist use in latter area.

Changes brought about by pastoralism are also visible in the relief, especially in the form of the numerous erosional niches to be found in both of the areas studied. Their distribution in a given area is conditioned by lithology, slope exposure and altitudinal zonation, though the persistence of the niches in the two areas differs. After thirty years since pastoralism was stopped in the Tatra Mountains most of erosional forms have been stabilised by vegetation. Similar changes are established on slopes cover by blockfields based on comparison of photogrammetric pictures from 1975 and 1993 years and confirmed by mapping in the field.

Generally although influence of tourism on slope morphodynamic is a little visible, the tendency to stabilisation of slopes dominate after ending of pastoralism in the Tatra Mountains.

SOIL EROSION AND ECONOMY – CAUSES AND EFFECTS OF LAND USE CHANGES IN THE WOLFSGRABEN, GERMANY

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In this case study we examined the land use history and the geomorphologic development of the Wolfsgraben during the late Holocene. The investigation area is situated next to the city of Bamberg in Northern Bavaria, Germany. The Wolfsgraben is a several meters deep and about 400 m long ravine covered with forest. It stretches from the margin of the hilly areas of the Triassic benchland onto the floodplain of the river Main. Maps and written documents prove intensive land use began in the 14th century. A detailed soil stratigraphy revealed that soil erosion had a big influence on the geomorphologic features. The study included the analysis of 14 exposures and 30 drillings as well as chemical soil analysis and the dating of charcoal and pottery.

The hilly areas west of the river Main near Bamberg were deforested between the 12th and the 14th centuries. Mainly the south-warding slopes were favoured for the cultivation of vine. Heavy rainfall events cut a several meters deep gully in that was later filled colluvial sediments. These sediments contain pottery from the second half of the 15th century in a depth of 1.67 m below the recent surface. Due to the 1618-1648 war population decreased during the first half of the 17th century, the land use was on a low level, fields were abandoned. With the following increase of population fields and vineyards were cultivated again. From the 18th century the cultivation of hop, financially supported by the archbishop of Bamberg, replaced the vineyards. Pottery from the 17th century was found in the uppermost colluvial layers. This indicates that extreme rainfall events caused the cutting of the 2 m deep recent gully between the 18th and the 19th century. Due to increased soil erosion and changing economic circumstances land use ceased at the end of the 19th century and forest started to occupy the slopes.

In the recent bottom line of the Wolfsgraben over 5 m of Late Holocene sediments cover the Triassic sandstone basis. The total sheet erosion rate between the 14th and the 17th century was approximately 70 mm, i.e. 0.17 mm a^{-1}. In the latest linear erosion event eroded a volume of 1 000 m^3. The intensive land use enabled increased soil erosion caused by heavy rainfall events. Peaks of linear erosion were in the 14th and again in the 18th century. Due to the soil erosion the soil fertility of the slopes dramatically decreased and today there are many areas where no humic horizon is preserved.

GEOMORPHIC HAZARDS IN THE HIMALAYAN REGION: ENVIRONMENTAL IMPACTS AND MITIGATION MEASURES

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Being in a seismically active zone, Himalayan mountain slopes are destabilised by various anthropogenic activities. This resulted into various geomorphic hazards and mass wasting particularly in the form of landslides, rock falls etc causing loss of human life and property. In August 1998 many landslides occurred in the Garhwal Himalaya. Earlier Kullu valley also experienced a massive landslides in Monsoon season. In August 1998 at Malpa, Pithoragarh District, a five metre high landslides of rock and water wiped out the human settlement causing loss of human lives. This landslide created an embankment of sixty metres in height on the course of river Madhyamaheshwar Ganga near Monsana, blocking the river and created a natural lake of 3 km. in length. The blockage of the river caused threat of a major flood downstream from the site in case of a sudden break of the embankment. The area experiences landslides every year during rainy season. The present landslide is the combined effect of heavy rain fall, the presence of weak structure and neo tectonic movements. Road construction and frequent blasting have spelled doom for the fragile region. Construction of roads means that these fragile areas are opened to human contact. Blasting large obstructive rocks with dynamite and the resultant rock debris not only work to destabilise the slopes, but also release residual stress on the slopes. Similar landslides also occurred at Rudraprayag, Ukhimath and Dehradun district in Uttar Pradesh. On the basis of the experience from the Himachal and Uttar Pradesh Himalaya, it is found that the natural absence of vegetation in the higher reaches of the catchment areas also contributes to frequent landslides. Apart from bringing down large quantities of sediments, landslides become a major cause for devastating floods because they block the narrow gorges. They are normally marked by a sudden change in the gradient of a tributary stream, confluence and weak geological conditions in the catchment of the tributary. The formation of landslide dams is a common sight in the Himalaya. Large scale deforestation and faulty farming practices have also led to soil erosion according to local people. The change in the cultivation patterns is another factor for landslides. A large number of people have shifted to terrace farming and horticulture. Terrace farming requires vast tracts of denuded land and also lot of water. The crop pattern has also changed. Villagers now fall prey to the less soil-binding crops such as rice instead of millets, more suited to this area. Local crops like millets and maize have disappeared while commercial crops and water intensive crops like paddy are grown. This makes the hills unstable. Earlier, forests would have protected the strength of the soil, but due to excessive deforestation, the protective cover has been drastically reduced. This has resulted in the creation of large number of rivulets in the hilly region.

Human activities need to be controlled since the region is prone to earthquakes. The government must plan development activities to check landslides. The Remote sensing technique is one of the vital tools for studying landslides in such inaccessible areas. Multi bands and multi dates data help in getting information about the changes and rate of increase of the landslides in a particular area. Different measures can be formulated for checking landslides by the help of remotely sensed data and field survey in the landslide prone areas. There is a need to increase community participation through awareness, co-operation and adopting measures for soil conservation. Bio-engineering is also emerging as a low cost technology for erosion and landslide control. Natural fibre-geotextiles made form Coir and Jute fibres in Woven forms have been used extensively as the traditional ground engineering material for erosion control followed by growth of vegetative cover in few areas.

WATER EROSION CONTROL IN CONDITIONS OF GEOMORPHOLOGICALLY DISSECTED AREA

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The loess hilly land of Trnava has typical occurrence of loamy, moderately till severely erodible Haplic Luvisols. The pilot region of the co-operative farm Kočín has been farming in the conditions of the erodible farmland, where water erosion (i.e. runoff - sedimentation) has been actual practically on 100 % of the territory. Runoff is actual on the area of 86 %, sedimentation in remaining 14 % of the area. In this region we have suggested following anti-erosion proposals for:

- slightly eroded soils, slope 0-3°, 12.3 % of total area
- moderately eroded soils, slope 3-7°, 52.5 %) of total area
- severely eroded soils, slope 7-12°, 21.2 % of total area
- very severely eroded soils, slope over 12°, 14 % of total area.

Complete anti-erosion agricultural use requires a perfect organisation of landscape pattern mainly in respect to conservation tillage. We have tried to propose optimal terrain geometry based on some geomorphological attributes as contour lines, orthogonal lines and sloping. Anti-erosion design is similar to bands established along contour lines perpendicular to orthogonal lines. We have taken into consideration field blocks size and location, field routes availability for agrotechnics, sloping degree. The conservation cropping system, including green protective areas, have been suggested for each compact block. In some cases newly formed field blocks were found. Proposed landscape scheme allow to establish effective anti-erosion measures with minimum of costs and with enormous benefit for agriculture practice.

GEOMORPHIC RESPONSE TO LAND USE CHANGES IN THE MYJAVA HILL LAND, SLOVAKIA

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The aim of the paper is to elucidate the geomorphic response to land use changes in the Myjava Hill Land from the beginnings of its settling up to the present time.

The Myjava Hill Land represents a low, plateau-like geomorphic unit situated in Western Slovakia. The duration of anthropic interference in this territory, in association with its specific historical evolution, is not longer than 8 centuries, with an exception of the narrow marginal belt in W and SW, where the settlement is from the period of the Great Moravian Empire and on some isolated places even from remoter past. The first bigger invasion of settlers to the inland of the Myjava Hill Land is dated back to the 1st half of the 14th century, but the main wave of the settling is associated with the so called "kopanitse" colonisation, taking place since the 2nd half of the 16th to the end of the 18th centuries, when it culminated. Substantial part of the Myjava Hill Land was gradually deforested and agriculturally utilised. The landscape of this specific, kopanitse region was typical for mosaic of small, narrow plots arranged into blocks with the same, either contour or gradient cultivation, alternating with pastures, meadows and forest patches.

The large-scale, stage-like transformation of originally forested landscape into the farmland created conditions for marked intensification of linear (gully), as well as areal water erosion. The result of gullying was formation of the extensive network of permanent gullies, acquiring locally even badland-like features. The biggest gullies reach the depth up to 15-20 m, exceptionally even 30 m. Gullies are controlled both topographically and anthropically. Topographically controlled gullies originated mostly in bottoms of dells and dry valleys. More frequent anthropically controlled gullies originated prevailingly either along artificial landscape elements (i.e. access roads, field boundaries, banks, lynchets, headlands, drainage furrows, etc) or on overgrazed pastures.

The slope portions, utilised as fields and not suffered by linear incision of gullies, were exposed to areal lowering. The slope lowering represents the total geomorphic effect of long-term operation of tillage erosion combined with accelerated areal water erosion. This phenomenon proceeded differently on slopes with contour and gradient cultivation. The difference is based on: i) different mutual proportion of above processes taking part in the slope lowering and ii) different mechanism of lowering. The common final effect of this phenomenon under both type of cultivation is partial, locally even total removal of soil.

THE WATER EROSION PROCESS ON THE BACKGROUND OF OUTFLOW CONDITIONS CHANGES IN UPLAND CATCHMENT

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The investigations of outflow denudation quantity were led in Mielnica Stream catchment in the hydrological years 1977/78-1993/94. The object is situated in the Trzebnica Hills area, considered as one of the most eroded regions of Poland. Daily bathometrical measurements of suspended load and observations of hydrometeorological conditions were made. Investigations were extended by analysis of washed out chemical compounds in years 1987/88-1989/90.

The character of agricultural production has changed as a result of an economic transformation in Poland since 1990. Looking for new ways of agriculture production in the catchment, fish ponds were built in 1997. The outflow denudation investigations were restarted in the year 1998. In this article the amounts of carried out matter are presented on the background of changes in the catchment.

Preliminary data analyses show differences between two investigation periods mentioned above. In the period 1977/78-1993/94 monthly sediment yield ranged from 5.5 to 16 504.1 $kg.km^{-2}$ and the mean annual one was 8 782.2 $kg.km^{-2}$. In current investigations the minimum monthly sediment yield was 6.2 $kg.km^{-2}$ and the maximum one - 300.9 $kg.km^{-2}$. The annual sediment yield was 799.7 $kg.km^{-2}$. In the year 1998/99 about 23.3 kg of NPK was washed out from one square kilometre. The maximum monthly value of chemical denudation yield was 4.2 $kg.km^{-2}$ NPK and the minimum one 0.76 $kg.km^{-2}$. In the years 1977/78-1993/94 monthly chemical denudation yield ranged from 0.6 to 11.8 $kg.km^{-2}$ and the mean annual one was 45.9 $kg.km^{-2}$.

SOIL WATER EROSION RISK ASSESSMENT OF SLOVAKIA USING GIS

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The paper presents an approach of GIS data integration for the soil water erosion risk assessment at regional scale (1:500 000). On the whole territory of the Slovak Republic two aspects were studied - potential soil erosion risk and actual soil erosion risk. While the ***potential soil erosion risk*** indicates the susceptibility of land to erosion irrespective of existing land cover/management ***actual soil erosion risk*** refers to estimated present risk, taking into account contemporary land cover and management practices.

The assessment was based on principles defined in the Universal Soil Loss Equation and was modified for application at regional level. The following model input parameters were applied: *rainfall erosivity* (total kinetic energy of rainfall event multiplied by its maximum 30-minute intensity), *soil erodibility* (derived from soil texture), *potential of relief* (computed from digital elevation model), *protective function of land cover/management* (derived from CORINE Land Cover data representing the status in 1990s). The derived input parameters as well as the final values of potential and actual erosion risk were handled in raster data model with grid resolution 50 metres as indexes (weight coefficients) rather than absolute values.

The results have confirmed that GIS data integration and analysis is an efficient approach for obtaining information on spatial variability of soil water erosion at the regional scale. The study revealed that more than 75 % of the territory of Slovakia is potentially endangered by soil erosion risk. About 48 % of the country have land cover (especially forests) with high soil conserving efficiency that mostly coincides with areas having high potential erosion risk. This means that uncontrolled timber exploitation or forest degradation by pollution can create conditions for accelerated erosion that could result in complete soil loss. On the other hand in Slovakia there is a high percentage of areas with very low soil conserving efficiency (34 %). Quite large parts of land with weak protective function of land cover are juxtaposed on potentially endangered areas. In these areas the non-proper agrotechnics or crop rotations result in accelerating the erosion processes.

At present the two land cover databases are available for the whole country, representing late 1970s and early 1990s respectively. The availability of these data as well as prospective new mapping activities will enable to assess also the changes in actual soil water erosion risk.

THE INFLUENCE OF THE PLANT COVER AND LAND USE ON THE SLOPE WASH AND EXPORT OF THE SUSPENDED MATTER FROM THE DRAINAGE BASIN (CASE FROM THE CARPATHIAN FOOTHILLS)

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The aim of this paper is to present the influence of the plant cover and land use on the slope wash and export of the suspended matter from the Stara Rzeka catchment (22.4 km^2) and its sub-catchment Dworski Potok (0.3 km^2). The investigation of slope wash was carried out on the slope (Aug. 1989-Oct. 1990) and on the plots (1989-1991). The transport of suspended mater was determined in the channels of Stara Rzeka and Dworski Potok (1987-1991).

The Stara Rzeka drainage basin is situated in the marginal part of the Carpathian Foothills, in the northern part of Wiśnicz Foothills between two large geographical units: the Carpathian Mountains to the south and the Sandomierz Basin to the north. It is characterised by a typical foothill relief, connected with different resistance of flysch and Miocene deposits.

The ridges and the slopes are covered with thick, loess-like formations. The valley floor is incised by erosional channel. The slopes and the river bed are separated by the alluvial plain, which in its footslope part is covered with deposits of prolluvial origin. The area is agriculturally used but unlike in other foothill catchments is well-forested (41.3 %).

The Carpathian Foothils have been subject to particularly strong anthropogenic transformation since Middle Ages, which is connected with deforestation and subsequent land cultivation. The present plot layout comes as a result of the medieval system of plots, stretching between the road in the valley and the forest. The fields are traditionally ploughed along the slopes (perpendicularly to contour line). Density of roads is high due to the mosaic of fields belonging to different owners.

The dominant process is slope wash, which is occasional. The days with precipitation covered 42.2 % of the study period but the number of days on which slope wash occurred – covered only 6.1 % (for the pastureland) and 3.0 % (for the tree-covered edge). The slope wash events did not take place simultaneously at all sites. Thus the same rainfall occurring even within a short and uniform slope does not have to bring about the soil wash everywhere. The total number of the events was not determined by the rainfall parameters but by the hillslope shape and the vegetation cover. The soil material is deposited within the area of flattened footslope and at the border with the tree-covered edge. Within the tree-covered edge the amount of the material is insignificant and its transport takes place only during rainfalls of the highest intensity. Thus the tree-covered edge is a barrier preventing the material from reaching the valley bottom and the stream channel.

The slope wash process is very intensive during heavy rainfall if the hillslopes are ploughed and unprotected by a dense cover of vegetation. Particular segments of the slopes function independently. The material is transported mainly by longitudinal furrows and accumulated at the end of a particular field. The consequence is the flattening at the boundaries of the segments and the irregular slope profile. However in the segments adjacent to the valley bottom the material is accumulated at the foot of the slope.

Transport of the suspended matter in the Stara Rzeka takes place all the year round; in the Dworski Potok it stops for 11-25 days a year as a result of lack of stream flow. The amount of the

suspended matter is different in particular years, half-years and months, depending on their „humidity". The rhythm of suspended matter export is related to the river flow. In case of export short high flow events play a greater role.

In the course of a year 276 tonnes in 1990 and 1695 tonnes in the 1987 of suspended matter were exported from the Stara Rzeka drainage basin and from 0.6 to 0.9 tonnes in Dworski Potok catchment respectively.

As most of the slope wash material is accumulated at the foot of the slope and in valley bottoms, it does not reach the river bed. Most of the suspended matter comes from the bed of the Stara Rzeka River, other streams and their immediate surroundings. In the bed of the Stara Rzeka River, which is in a deep erosional channel, the suspended material comes from washed-away river banks. The supply of the material is facilitated by the winding course of the river with numerous bank undercuts. The beds of small foothill streams are mostly vegetated and during high flow events, the reserves of the material available for transport are quickly exhausted. Thus the supply area covers just a small percentage of the catchment.

The slope and channel subsystems in the foothill catchments are weakly linked and only locally. Footslope deposits and flat valley bottoms constitute a third subsystem of a catchment, which separates the slope and the channel

INFLUENCE OF CONTEMPORARY HILLSLOPE VEGETATION DEVELOPMENT ON CHANNEL MORPHOLOGY AND SEDIMENT SIZE: THE STUDY CASE OF THE UPPER-ROUBION WATERSHED (DIOIS, FRENCH SOUTHERN PREALPS)

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The southern French Prealps are characterised by a strong vegetation development on hillslopes since the beginning of the 20th century. This evolution is mainly induced by agricultural decline, which started at the beginning of the 19th century and accelerated after the first world war. A secondary reason was the planned reafforestation of degraded lands. The progression of forest and scrub cover on hillslopes is often considered as an important control on channel changes. The Upper-Roubion example allows us to analyse the relation between land-use evolution and channel history because this watershed has not been affected by other human disturbances such as gravel mining or torrent control works which could interfere with vegetation increase.

The history of hillslope vegetation was studied in two administrative units (les Tonils and Bézaudun-sur-Bine) which correspond to the two main upstream tributaries of the Roubion River (Soubrion and Bine streams). Many different documents were analysed cadastral survey and other archives of 1826 and aerial photographs of 1956 and 1991. Three land-use maps were drawn and a multi-date analysis was done. Field work and aerial photograph analysis were done on alluvial reaches of the main corresponding rivers in order to characterise channel changes during the 20th century.

Three main observations are noticeable: (i) a strong decrease of farmlands between 1826 and 1991 which is related to an important development of forest cover during the same period. Areas colonised by forest during this period represent 21 % of the two watersheds. If we consider areas colonised by protective land-use types (forest, scrub and pasture lands), these represent 30 % of the study site; (ii) some significant differences are observed between the two watersheds: relative increasing of protective land-use types is, respectively for the Bine and Soubrion watersheds, 12 % and 35 % between 1826 and 1956; (iii) this evolution is mainly induced by a spontaneous vegetation dynamics and only a few areas were characterised by planned reafforestation.

Information relative to channel forms and sediment size and to channel changes were collected in 3 reaches corresponding to the main alluvial trunks of the Roubion River and its two main upstream tributaries Bine and Soubrion streams. Three main contemporary fluvial changes are observed (i) channel degradation which amounts to a mean value of 1 meter between 1931 and 1996 on the Roubion River; (ii) active channel narrowing between 1956 and 1991; (iii) pavement development in some reaches. Statistical relations which were obtained between these three types of changes suggest some physical links between them. It is suggested that channel degradation is controlled by channel narrowing and that pavement development is induced by a progressive downstream winnowing of fine particle which are not renewed from upstream sediment sources. The decreasing geomorphic activity of sediment sources is considered as the result of the vegetation development on hillslopes. The comparative analysis of channel changes between Bine and Soubrion streams suggests that these are controlled both by land-use changes and geomorphic potential of watersheds.

THE IMPACT OF HISTORICAL AND ACTUAL LAND USE CHANGES ON SOIL EROSION RISK: A CASE STUDY IN CENTRAL BELGIUM

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The potential for surface runoff and soil erosion is very much affected by land use and cultivation. Therefore the modelling of land use changes is important with respect to the prediction of soil degradation and its on-site and off-site consequences.

Via the comparison of 4 historical topographic maps (1774, 1840, 1930 and 1990) the land use changes during the past 250 years in a rural study area in the Central Belgium were analysed. A combination of land use transition maps with biophysical land properties like slope gradient, soil texture and soil drainage shows that farmers use certain decision rules when converting forest into arable land or vice versa. During periods of increasing pressure on the land forests were cleared mainly on land areas with low slope gradients and favourable soil conditions, while in times of decreasing pressure land areas with steep and unfavourable soil conditions were taken out of production. These decision procedures were compared with present-day data of set-aside of arable land within the framework of the Common Agricultural Policy of the European Union (EU-CAP). The results reveal that the basic decision procedures for land use conversion in rural areas in Central Belgium have remained the same during the last 250 years.

Next, by means of stochastic simulations based on land use transition probabilities possible future land use patterns were generated. The outcome of these simulations was used to assess the soil erosion risk under different scenarios. The results indicate that even a relative limited land use changes -from forest to arable land or vice versa- have a significant effect on regional soil erosion rates and sediment delivery. The relation between the land use change ratio and the regional soil erosion risk can be described by means of a power function.

DYNAMIC MODELLING OF THE GEOMORPHIC RESPONSE TO LAND USE CHANGES FOR IRRIGATED LANDS IN A SEMI-ARID MOUNTAINOUS ENVIRONMENT

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This paper presents (i) an analysis of the geomorphic response to land use changes in a semi-arid mountainous catchment, located in the Austro Ecuatoriano, Ecuador. The catchment of Santa Isabel has a surface area of 900 ha and is characterised by a strong precipitation gradient: annual precipitation is ca 450 mm and decreases to ca. 200 mm at the lowest points of the catchment. The analysis of aerial photographs from different dates showed that the land use in the catchment is highly dynamic. Over a period of 25 years ca. 83 ha of arable land were abandoned while ca. 70 ha were taken into production, resulting in a slight decreases of the total area of arable land of ca. 0.5 ha per year. Changes in land use are not spatially homogeneous. Steeply sloping parcels on unstable geologic formations and located far away from the farms are preferably set aside. Land taken into cultivation is mostly located on gently sloping convex areas that are close to newly built areas and arterial roads. At the same time, the forested area increases due to a regeneration of the natural vegetation on fields set aside in the late 1970s and early 1980s: most of these areas are located on old mass movements and are characterised by thin leptosols.

Our analysis revealed a complex interaction between the occurrence of water erosion and land use dynamics in the study area. There is a spatial decrease of the areas susceptible to water erosion as the regeneration of the vegetative cover efficiently protects the set-aside areas. Furthermore, the land that has recently been taken into production is terraced, thereby reducing water erosion to a minimum. However, the spatial decrease of the areas affected by water erosion does not imply that the overall sediment production in the catchment also diminishes. Air photo analysis reveals an intensification of water erosion on the uncultivated steep slopes, whereby half of the areas that were affected only by sheet and rill erosion 30 years ago are now incised by deep gullies. This is mainly due to inadequate water management in the new areas taken into cultivation.

ALLUVIAL SEQUENCE AND CHANNEL PATTERN CHANGES AS INDICATOR OF RIVER RESPONSE ON HUMAN IMPACT, THE SOŁA RIVER, THE CARPATHIAN FORELAND, POLAND

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The Soła river is a gravel-bed tributary of the Vistula river. It is 90 km long and drains an area of 1 375 km^2. It cuts across the northern slope of the Western Beskidy Mts. and the Carpathian foreland. In the fore-mountain reach an average gradient of the Soła valley is 2.2 $m.km^{-1}$. Nowadays, maximum discharges reach 889 m^3s^{-1} (1 300 m^3s^{-1} before dam constructions), the mean discharge being 20 m^3s^{-1}. The hydrologic regime is characterised by great variability of water stage and discharge.

Cartographic materials from the last 220 years show great changes in the Soła channel pattern on the Carpathian foreland. The late 18th and 19th centuries maps show a braided river with the river-bed width up to 1 km. The Soła river had multiple active channels of a various geometry whose traces are differently visible within the lower level of the alluvial plain. As a result of regular engineering works started at the beginning of the 20th century, secondary channels were cut off and the dam reservoirs in the upper part of the catchment were built. Because of the intention to create a single straight channel only in some reaches of the alluvial channel the braided pattern can be found at the present-day. In all other reaches the river course is straighter. The river-bed is up to 200 m wide.

In the vicinity of Łęki (13 km downstream from the Beskidy Mts. border), the at least 220 years old alluvial plain was undercut. In this 3 - 4 m high undercut the gravely-sandy deposits are characterised by very poor sorting and considerable thickness. These 1 - 1.5 m thick deposits consist layers of usually massive up to 20 cm diameter gravels with a fine-grained matrix. They could have been deposited during very high velocity of flood water and large supply of material from eroded banks and upper parts of the catchment. Within these alluvia there are thin layers (up to several cm) of finer gravels of similar size. That indicates the redeposition of a part of previously deposited material during the falling water stage. The gravely-sandy alluvia are covered by fine-grained overbank sediments 1 - 1.5 m thick.

About 200 m downstream, in the undercut of the western (left) bank, younger alluvia are visible, deposited in the river after engineering works. These 1 - 1.5 m thick alluvia consist thin layers of massive, better sorted gravely-sandy deposits with gravels up to 12 cm diameter. They are interbedded with fine-grained sediments - 0.25 m thick grey muddy layers probably deposited from suspension, covered by 0.5 m thick sands with horizontal and cross laminations.

Because of reduction of high discharges, limited supply of coarse material to the alluvial channel, good pavement of gravel bar surfaces and often dense vegetation covers, the present-day channel transformation consists mainly in bar surfaces remodelling. New bars originate very seldom. Then sources of alluvia possible to transportation during next floods are limited. Only fine material can be transported and deposited in the form of sand shadows and covers within the narrow river-bed.

THE ROLE OF DEBRIS-MUD FLOWS IN DEVASTATION OF ECONOMIC INFRASTRUCTURE IN THE FLYSCH CARPATHIANS

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The human being has inhabited river valleys since the past and he was endangered by different disasters. He occupied the high terraces outside the reach of high water to avoid floods. After the river channels regulation works the present settlement occupies the flood terraces and gentle slopes of pediment character formerly used by agriculture. During long lasting and heavy precipitation there occur not only disastrous water levels in the valleys but also debris-mud flows, which destroy economic infrastructure. During the last 50 years the greatest intensity of those processes was recorded in 1958, 1960, 1970, 1980, 1996 and 1997. The floods occurred after long lasting, particularly intensive during last 3 days (200-350 mm) or after 2 hrs lasting heavy rainfall (100-150 mm). Slope stability ration was exceeded. Debris mud-flows occurred in 1997 at unparalleled scale. The reason for those processes were thick ground, weathering-debris or colluvial (debris-argillaceous) covers which in the result of water absorption became plastic, flow down the slopes with great speed and then down the valleys which are cut in the beskidian slopes.

There have been distinguished three types of valleys modelled by debris-mud flows: 1) V-shaped valleys cut in the beskidian slopes, very steep with inclination often exceeding 100 ‰, 2) big flat-bottomed beskidian valleys dissecting the montane ridges, 3) the main valleys (the Soła, Skawa, Raba, Dunajec and others) and dales with wide, terraced bottoms and small inclination not exceeding 10 ‰. Structural debris-mud flows move with great speed on steep slopes and in V-shaped valleys and all obstacles are destroyed. Structural flows destroy forest areas and trees growing on the slopes are uprooted and broken. There are created numerous corrasional channels, V-shaped valleys are deepened and transported material is deposited as big debris-mud cones. The whole hydrological infrastructure is destroyed. In big flat-bottomed valleys collecting waters from V-shaped side valleys there are turbulentive debris-mud flows. remains of them are wide, stone fields which are also on flood terraces used as pastures or arable land. In the lower parts of those valleys accumulation of river debris prevails. In those valleys hydrological infrastructure, roads, bridges, houses and regulated banks of rivers and streams are destroyed. Turbulentive flows influence flood processes in bottoms of bigger valleys and dales in which stone fields in the river beds are transported down the rivers. Side valleys supply great amount of river debris, which is accumulated in intermontane or foreland valleys. The damages concern mainly agriculture, economic and transportation infrastructure.

During long lasting and heavy precipitation debris-mud flows are link between gravitational rocky masses movement and fluvial processes and they influence the course of erosion, transportation and accumulation processes in big valleys. Those valleys are supplied with great amount of material from structural and debris-mud flows. The damages caused by debris-mud flows in 1997 in the Beskid Wyspowy were estimated for 50 000 000 $. There should be a complex regulation and management of all montane catchment areas taking into account aspects of the whole geographical environment. Local regulations disturb natural processes of landscape development and rivers, after leaving such a part of valley, destroy lower situated areas with greater strength. Regulation of stream channels will not bring any positive results if the slopes are left as they are. They are stores of great amount of argillaceous-debris material. The wrong structure of forest areas formed by many centuries bad forest economy should be also changed.

THE INFLUENCE OF EXTREME RAINFALL IN WATERSHEDS WITH LARGE FORESTATION ON RIVER-BED PROCESSES IN THE BESKIDY MOUNTAINS

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In the Beskid Wyspowy range in July 1997 large amount of rainfall appeared reaching 120 mm in about 2 hours. The heavy rainfall was preceded by small rain events of low intensity. Particularly threatening effect were recorded in the Kamionka Mala watershed, the tributary of the Lososina river discharging into the Dunajec river. The watershed cuts the left steep slope of the Lososina river built of resistant magurski sandstone. A few kilometres long valley is characterised by high forestation coefficient. The stream winds its way in its central part what evidences the tendency for accummulation in this place. In some divisions of the river-bed the bands were built, especially in places where the road embankment neighboured the river-bed. Both the river-bed bands and older stone bridges separating the river-bed maintained their shape and construction after the flood. The overflow wave with large material (up to 0.8 metres in diameter) filled up the river-bed in many places causing damage to the road embankment after crossing the concrete bands and large bridges improperly anchored to the bank. In narrower places a few metres wide the overflow wave reached ca. 4 metres in heigh. It is visible after erosion traces i.e. in the cemetery. During a few hours, the overflow wave with a short time of concentration fitted the erosion curve to such extreme runoffs. The scale of the processes showed on various photographs proves unusual dynamics of river-bed processes in short time. People, living in the watershed basin for tens of years, have not been observing such huge transformation of the river-bed. The extreme rainfall of high intensity preceded by widespread rains, prove the catastrophic history of nature. The regularities set in normal condition change significantly in extreme ones. The significance of forest in rainfall transformation also change. The forest in the Beskidy relief with such rainfall loses the possibility of lowering extreme runoffs, lengthening the duration and concentration of oveflows. This regularity is confirmed by previous research conducted by the author in the Beskid Niski range.

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